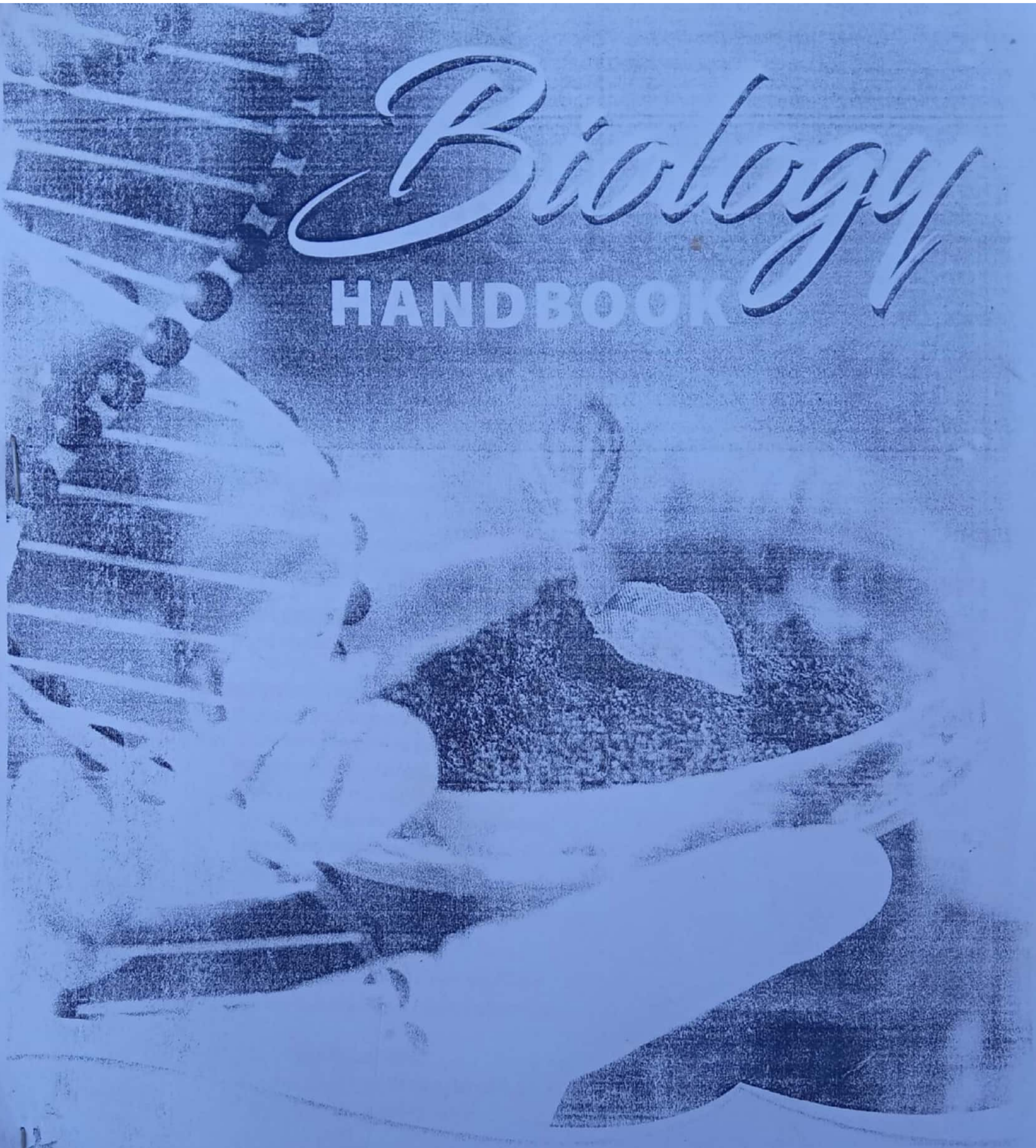
Biology
HANDBOOK



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BIOLOGY HANDBOOK

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PLANT KINGDOM

CHAPTER - 1 : LIVING WORLD

- **Earnst Mayr** has been called as "The Darwin of 20th century" He worked on Taxonomy, Zoogeography, Evolution, Systematics and History & Philosophy of biology. He gave the biological concept of species.
- The number of species that are known and described ranges between 1.7 – 1.8 million
- **ICBN** – International Code of Botanical Nomenclature
- **ICZN** – International Code of Zoological Nomenclature
- Each biological name is made up of two components, generic name and specific epithet. This system is called as bionomial system.
- Biological names are generally in Latin and written in italics. They are latinised or derived from Latin irresepective to their origin.
- Both the words in a biological name, when handwritten, are separately underlined, or printed in italics to indicate their Latin origin.
- Classification is the process by which any thing is grouped into convenient categories based on some easily observable characters.
- The group included in taxonomic categories is called as taxon.
- Characterisation, identification, nomenclature and classification are the processes that are basic to taxonomy
- Category is a part of overall taxonomic arrangement and all categories together constitute the taxonomic hierarchy
- As we go higher from species to kingdom the number of common characteristics goes on decreasing.
- **Herbarium** is a store house of collected plant specimens that are dried, pressed and preserved on sheets
- **Keys :** The keys are based on the contrasting characters generally in a pair called couplet. Each statement in the key is called a lead.
- Keys are generally analytical in nature.
- **Flora** : It contains the actual account of habitat and distribution of plants of a given area. These provide the index to the plant species found in a particular area.
- **Monograph :** It contains complete informations on any one taxon.

CHAPTER - II : BIOLOGICAL CLASSIFICATION

- Aristotle was the earliest to attempt a more scientific basis for classification.
- **Aristotle** divided animals into two groups (1) Having red blood cells and (2) Do not having red blood cells.
- **R.H. Whittaker's Classification** is phylogenetic classification.
- Archaebacteria differ from other bacteria in having a different cell wall sturcture and this feature is responsible for their survival in extreme conditions.
- Some cyanobacteria can fix atmospheric N_2 in their specialised cells called heterocysts. eg. ***Nostoc*** & ***Anabaena***
- In diatoms the cell walls form two thin overlapping shells, which fit together as in a soap box.
- The cell wall of diatoms (chrysophytes) are embedded with silica and thus the walls are indestructible.
- **Red dinoflagellates** undergo very rapid multiplication so they make the sea appear red, called as red tides.
- The cell wall of fungi is composed of chitin and polysaccharides.
- Some fungi can live as symbionts in association with algae (lichen) and with roots of higher plants as mycorrhiza.
- In fungi the sexual cycle involves.

  (1) Plasmogamy (2) Karyogamy (3) Meiosis.
- Phycomycetes are found in aquatic habitats, on decaying wood on moist or damp places or as obligate parasites on plants.
- In ascomycetes and basidiomycetes dikaryotic (n + n, two nuclei per cell) condition is also found called as dikaryophase.

- Many members of ascomycetes like morels and buffles are edible fungi.
- Members of basidiomycetes are mushrooms, bracket fungi and puffballs. They produce basidiospores exogenously on their basidium (pl. basidia). Some times basidia are arranged in fruiting bodies called basidiocarp.
- **Deuteromycetes :** they are commonly known as imperfect fungi because they reproduce only by asexual or vegetative reproduction, not by sexual reproduction. They produce septate and branched mycelium. Some members are saprophytes or parasites while a large number of them are decomposers of litter and help in mineral cycling.

CHAPTER - III : PLANT KINDGOM

- Kingdom plantae includes all eukaryotic chlorophyllous autotrophic organisms. A few members are partially heterotrophic such as insectivorous plants or parasites. Bladderwort and venus fly trap are examples of insectivorous plants and ***Cuscuta*** is a parasite.
- The **artificial system** gives equal weightage to vagetative and sexual characteristics, this is not acceptable since the vegetative characters are more easily effected by envirnoment.
- **Natural classification** is based on natural affinities among the organisms and consider not only the external features but also internal features.
- The phylogenetic systems are based on evolutionary relationships between the various organisms.
- **Numerical taxonomy** is based on all observable characters. Number and codes are given to all the characters and these data are made and processed by the help of computer for making the numerical taxonomy.
- **Cytotaxonomy :** cytotaxonomy is based on cytological informations like chromosome number, structure and behaviour.
- **Chemotaxonomy :** Chemotaxonomy uses the chemical constituents of the plant.

ALGAE

- Algae are highly variable in form and size, they are unicellular (microscopic), colonial, filamentous, and also form massive plent bodies (kelps)
- **Isogamy :** Fusion of similar gametes in size is isogamy. These gametes may be motile (***Ulothrix***) or nonmotile (***Spirogyra***).
- **Anisogamy :** Fusion of two gametes dissimilar in size is anisogamy eg. some species of ***Chlamydomonas***.
- **Oogamy :** Fusion between one large, nonmotile (static) female gamete and a smaller, motile male gamete is termed as Oogamy. eg. ***Volvox, Fucus.***
- At least a half of the total CO_2 fixation on earth is carried out by algae through photosynthesis.
- Many species of ***Porphyra***, ***Laminaria*** and ***Sargassum*** are among the 70 species of marine algae used as food.
- Many algal products like algin (from brown algae) and carrageen (red algae) are used commercially. Agar-agar (from ***Gelidium*** and ***Gracillaria***) are used to grow microbes and preparation of ice creams and jellies.
- ***Chlorella*** and ***Spirullina*** are unicellular algae, rich in proteins and are used as food supplements even by space travellers

CHLOROPHYCEAE (Green algae)

- Most of the members of chlorophyceae have one or more storage bodies called pyrenoids located in chloroplasts. Pyrenoids contain protein besides starch.
- In green algae the cell wall is made of inner layer of cellulose and an outer layer of pectose.

PHAEOPHYCEAE : (Brown algae)

- The members of brown algae show great variation in size and form. They range from simple branched, filamentous forms to profusely branched form, which may reach a height of 100 meters.
- Their cellulosic cell wall is covered on outside by a gelatinous coating of algin.
- Food is stored in them as complex carbohydrate, laminarin or mannitol.

- The gametes of these algae are pyriform (pear shaped) and bear two laterally attached flagella.
- Common members of phaeophyceae are -- ***Ectocarpus*, *Dictyota*, *Laminaria*, *Sargassum* & *Fucus***

RHODOPHYCEAE (Red algae)

- Majority of red algae are found in marine water with greater concentrations in warmer areas.
- The reserve food in red algae is **floridean starch** which is very similar to amylopectin and glycogen.
- Sexual reproduction in red algae is Oogamous and accompanied by complex post fertilisation developments
- Examples of red algae are ***Polysiphonia*, *Porphyra*, *Gracillaria*, *Gelidium***.

BRYOPHYTA

- Bryophytes lack true roots, stem or leaves. They may possess root like, stem like or leaf like structures
- Main body of **bryophytes** is made of haploids cells and it produces gametes hence is called as **gametophyte**
- Sporophyte in them is not free living, but attached to the photosynthetic gametophyte and derives nourishment from it.
- ***Sphagnum*** provides peat that have long been used as fuel and also used as packing material for trans-shipment of living material because of its high water holding capacity.
- Mosses along with lichens are the first organisms to colonies rocks and hence are of great ecological importance.
- Mosses form dense mats on the soil, they reduce the impact of falling rain and prevent soil erosion.

LIVER WORTS :

- The plant body of liver wort is thalloid and the thallus is dorsiventral and closely appressed to the substratum
- The leafy members of liverworts have tiny leaf like appendages in two rows on the stem like structures
- Asexual reproduction in liverworts takes place by fragmentation of thalli or by the formation of specialised structures called gemmae (gemma-singular). Gemmae are green multicellular, asexual buds, which develop in small receptacles called gemma cups.
- The sporphyte is differentiated into a Foot, Seta and Capsule (***Marchantia***). After meiosis spores are produced within the capsule.

MOSS

- The gametophyte body of moss is made up of two stages.
  (i) Protonema – first stage produced from spore.
  (ii) Leafy stage – The second stage produced from buds of protonema.
- Vegetative reproduction in mosses is by fragmentation and budding in the secondary protonema.
- Common example of mosses are ***Funaria*, *Polytrichum*** and ***Sphagnum***.

PTERIDOPHYTA

- In pteridophytes the main plant body is sporophyte which is differentiated into root, stem & leaves. They have well differentiated vascular tissues.
- The leaves in pteridophyta are small (microphylls) as in ***Selaginella*** or large (macrophylls) as in ferns.
- Only few genera of pteridophytes show heterospory; they produce two types of spores. Macrospores (large) and Microspores (small).
- In heterosporous pteridophytes the female gametophytes are retained on the parent sporophyte for variable period. The development of zygote into young embryo takes place within the female gametophytes. This is precursor to the seed habit, considered as an important step in evolution.

GYMNOSPERMS

- In gymnosperms ovules are not enclosed in ovary walls and remain exposed both before and after fertilisation, so they produce naked seeds.
- Gymnosperms are medium sized trees or tall trees and shrubs.
- The giant redwood tree ***Sequoia*** is one of the tallest tree species.
- In gymnospemrs the stem may be unbranched (***Cycas***) or branched (***Pinus*, *Cedrus***)

- The leaves may be simple or pinnately compound.
- The leaves in gymnosperms are well adapted to withstand extremes of temperature, humidity and wind. In conifers, the needle like leaves reduce the surface area. Their thick cuticle and sunken stomata also help to reduce water loss. These are the xerophytic characters in gymnosperms.
- The male and female cones (strobili) may be produced on the same tree (***Pinus***) or on different trees (***Cycas***)
- In Gymnosperms the male and female gametophytes do not have an independent free living existence.

Lichens :

- Lichens are symbiotic associations between algae and fungi.
- The algal component of lichen is known as **phycobiont** and fungal component is known as **mycobiont.**
  - → Algal component – Autotrophic
  - → Fungal component – Heterotrophic
- In lichens algae prepare food for fungi and fungi provide shelter and absorb mineral nutrients and water for algae.
- Lichens are very good pollution indicators, they do not grow in polluted areas.

→ Most of the lichens are **ascolichen** (on the basis of fungal component).

→ Most common phycobiont in Lichens :- ***Trebouxia***

→ *Parmelia* species are used as a curry powder in India.

→ *Cetaria islandica* is used as laxative.

→ *Cladonia rangiferina* is commonly known as reindeer moss.

Viruses :

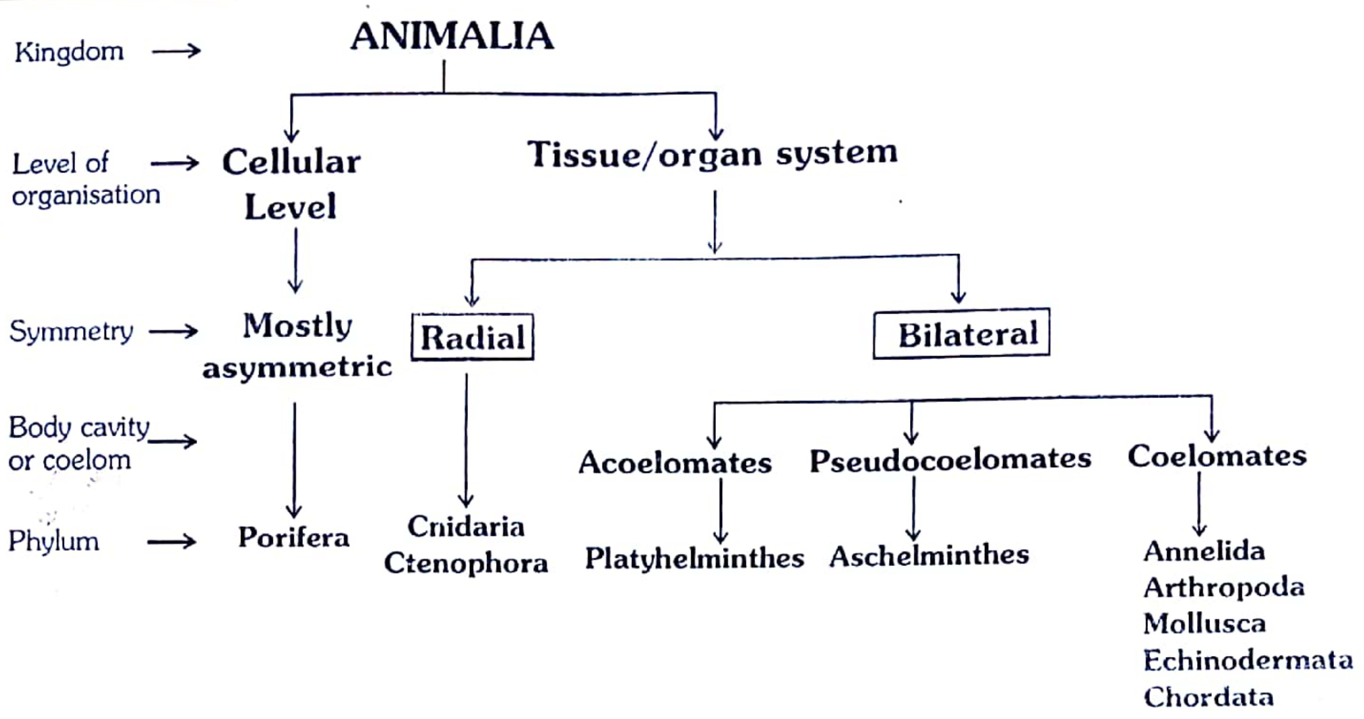
- The viruses are non cellular organisms that are characterised by having an inert crystalline structure outside the living cell.
- The name virus that means *venom* or *poisonous* fluid was given by Pasteur.
- Viruses are obligate parasite.
- Viruses are inert outside their specific host cell.
- In addition to proteins viruses also contain genetic material that could be either RNA or DNA.
- Generally, plant viruses are single stranded RNA viruses.
- Bacteriophages are generally double stranded DNA viruses.
- The protein coat of virus is called *Capsid* made of small subunits called capsomeres. These capsomeres are arranged in helical or polyhedral geometric forms.

Viroids :

- Discoverer - T.O. *Diener*
- They have only low molecular weight RNA, no protein coat.
- *Potato spindle tuber disease* is caused by potato spindle tuber viroid.

Note : Viruses. Viroid and Lichens are not included in five kingdom system of classification.

ANIMAL KINGDOM


Kingdom →
ANIMALIA
Level of organisation →
Cellular Level
Tissue/organ system
Symmetry →
Mostly asymmetric
Radial
Bilateral
Body cavity or coelom →
Acoelomates
Pseudocoelomates
Coelomates
Phylum →
Porifera
Cnidaria
Ctenophora
Platyhelminthes
Aschelminthes
Annelida
Arthropoda
Mollusca
Echinodermata
Chordata

INTRODUCTION

Animals show different types of of body organisation

(i) Protoplasmic level	Eg. – **Protozoa**
(ii) Cellular level	Eg. – **Porifera**
(iii) Tissue level	Eg. – **Coelenterata** & **Ctenophora**
(iv) Organ/organ system level	Eg. – **Platyhelminthes** onwards to **Chordata.**

Animals can be Asymmetric, Radial and Bilateral symmetric.

Most of the animals are **triplobastic**.

Flatworms are **Acoelomate**, Round worms are **pseudocoelomate** where as rest of the animals are **coelomates.**

Digestive tract is **incomplete** in coelenterata, ctenophora and platyhelminthes where as it is **complete** in rest of the phyla.

Modes of respiration can be Body surface, cutaneous branchial and pulmonary.

Circulatory system is **open** in Arthropoda, Mollusca, Echinodermata, Hemichordata and in Urochordata where as it is **closed** in annelida and rest of the chordates

Modes of Excretory system includes Flame cells, Nephridia, Malpighian tubules, Green glands and Kidneys in animals.

PORIFERA

Mostly marine, cellular level body organistation with **water transport system / Canal system** having ostia, osculum and choanocytes (Collar cell) etc.

Sponges are **hermaphrodite** and their Fertilization is **internal.**

Eg. – **Sponges,** Like – ***Sycon*** (Scypha), ***Spongilla*** (Fresh water sponge), ***Euspongia*** (Bath spange)

COELENTERATA

Mostly marine, radially symmetrical with stinging cell known as ***Cnidoblast***. Mainly two forms i.e. **polyp** & **medusa** which exibit alternation of generation **(Metagenesis)**

Eg. – ***Hydra Aurelia*** (Jelly Fish), ***Adamsia*** (Sea anemone), ***Pennatula*** (Sea pen), ***Gorgonia*** (Sea Fan), ***Meandrina*** (Brain coral), ***Physalia*** (Partuguese man-of-war).

CTENOPHORA

Exclusively **marine** popularly known as sea walnuts or **comb jellies** due to presence of 8-cillary comb plates which help in locomotion. They show Bioluminescence.

Eg. → ***Ctenoplana, Pleurobrachia***

PLATYHELMINTHES

They are known as **Flatworms** and mostly **endoparasitc**. Hooks and suckers are found.

Eg. → **Taenia,** (Tape worms), ***Planaria,*** *(High regeneration of capacity),* ***Fasciola*** (Liver Fluke), etc.

ASCHELMINTHES / NEMATODA

They are known as **round worm.** Complete Alimentary Canal with muscular Pharynx. **Sexual dimorphism** is well marked. Often male is small with curved tail where as Female is large & straight.

Eg. → ***Ascaris*** (Round worm), ***Wuchereria*** (Filaria worm), ***Ancyclostoma*** (Hook worm).

ANNELIDA

Body surface with **segments** or **metamere**. Possess Longitudinal and circular muscles. Parapodia help in swimming. In Nervous system, nerve cord is double, mid ventral, solid and gangliated

Eg. → ***Nereis, Pheretima*** (Earthworm), ***Hirudinaria*** (Blood sucking Leech).

ARTHROPODA

Arthropoda is the **largest** phylum with **jointed appendages** and chitinous exoskeleton. Mainly body is divided into **head**, **Thorax** and **Abdomen**. Few Arthropods have economic importance and few are vectors for various pathogens. statocysts balance organs are present

Eg. (i) Economically important insects – ***Apis,*** Bombyx, Laccifer

(ii) Vector – Anopheles, Culex, Aedes.

(iii) Gregarious pest – ***Locusta*** (Locust)

(iv) Living fossil – ***Limulus*** (king crab)

MOLLUSCA

It is the **second largest** phylum. Basically they are **soft body** and hence covered with calcareous shell. Normally body is divided into **Head, muscular foot** and **visceral hump**. Spongy fold **mantle** and rasping organ for feeding-**radula** is also found

Eg. ***Pila, Pinctada, Sepia, Loligo, Octopus, Aplysia, Dentalium, Chaetopleura*** (Chiton)

ECHINODERMATA

An exclusively **marine phylum** and having **spiny body.** Their larva is **bilateral** symmetrical where are adult is **radially symmetrical.** They have an endoskeleton of calcareous ossicus.

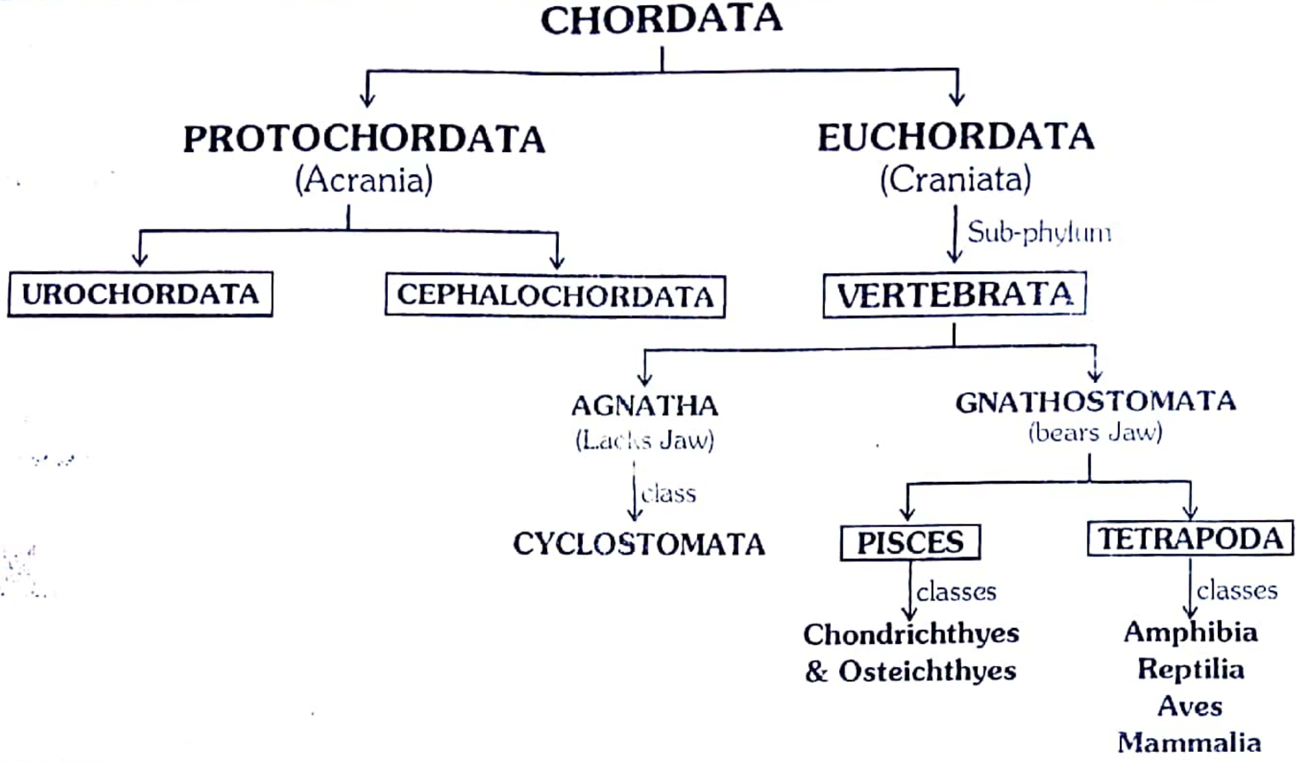
Unique **water vascular system** helps in locomotion, nutrition and respiration

Eg. ***Asterias*** (Star fish), ***Echinus*** (Sea urchin) ***Antedon*** (Sea lily), ***Cucumaria, Ophiura*** (Brittle star)

HEMICHORDATA

Earlier considered as sub-phylum of chordata. Body is divided into **proboscis, collar** & **Trunk.** Animals are worm like

Eg. → ***Balanoglossus, Saccoglossus.***


CHORDATA
PROTOCHORDATA
(Acrania)
EUCHORDATA
(Craniata)
Sub-phylum
UROCHORDATA
CEPHALOCHORDATA
VERTEBRATA
AGNATHA
(Lacks Jaw)
GNATHOSTOMATA
(bears Jaw)
class
CYCLOSTOMATA
PISCES
TETRAPODA
classes
Chondrichthyes
& Osteichthyes
classes
Amphibia
Reptilia
Aves
Mammalia

CHORDATA

Chordata are fundamentally characterised by presence of **Notochord, dorsal hollow Nerve** cord and **paired pharyngeal gills slits.**

- There are three sub-phylas of chordata –
  - (i) **Urochordata** – Eg. ***Herdmania, Ascidia, Salpa***
  - (ii) **Cephalochordata** Eg. ***Amphioxus*** or ***Branchiostoma*** (Lancelet)

    Urochordata and Cephalochordata are also known as **Protochordata**.
  - (iii) **Vertebrata** - This subphylum is divided as **Agnatha** and **Gnathostomata.**
- Agnatha do not possess jaw where as Gnathostomata **possess** Jaw.
- Cyclostomata are agnatha and considered as most primitive vertebrates. Gnathostomata has two super classes **Pisces** & **Tetrapoda**
- Class chondrichthyes (**Cartilaginous**) and osteichthyes (**Bony**) are pisces classes and bear **fins** for locomotion
- **Tetrapoda** divides into four classes - **Amphibia, Reptilia, Aves** and **Mammalia.** They have **two pairs** of Limbs and thus grouped under tetrapoda.
- **Amphibian** have adapted for both on Land and water where as **reptiles** are characterised by the presence of **dry** and **cornified** skin and thus considered as **successful terrestrial animals**.
- Fishes, Amphibians and Reptiles are **poikilothermic** (cold blooded) where as Aves and mammals are **Homothermic** (warm blooded). Birds with **feathers** on their bodies.
- Their fore limbs modified into **wings** where as hind limb are adapted for **walking, swimming** and **clasping.**
- The most unique mammalian charateristic is the presence of **mammary glands**. Skin is **hairy** and presence of **diaphragm** are salient features of mammals. **Pinna** are also present. All are **homeothermic animals**

MORPHOLOGY OF FLOWERING PLANTS

Modification of root, stem, leaf

ROOT

- Direct elongation of the radicle leads to the formation of primary root and lateral roots are called secondary tertiary roots, (are collectively called tap root system). eg most of the dicot plants (Mustard).
- In monocots primary root is replaced by the large numbers of roots which is originated from the base of stem called fibrous roots. eg – wheat
- Roots arise from parts of the plant other than radicle are called adventitious roots. eg. Grass, Monstera, Banyan.

MODIFICATION OF ROOTS

For food storage
Carrot Turnip (Tap root)
Sweet Potato (Adventitious roots)

For support
Banyan tree (Prop root)
Maize, sugarcane (stilt root)

For respiration
Pneumetophores
(Rhizophora)

STEM

It develops from the plumule. The main function of the stem is spreading out branches bearing leaves, flowers and fruits.

MODIFICATIONS OF STEM

(1) **For food storage-underground stem** (Potato, ginger, turmeric, zaminkand, Colocasia)

(2) **Stem tendrils** – Help plants to climb

e.g.– Gourds (Cucumber, Pumpkins, Watermelon) and grapevines

(3) **Thorns** – Protect plants from browsing animals

e.g – **Citrus, Bougainvillea.**

(4) **Phylloclade** – Perform photosynthesis

e.g. – **Opuntia (Flat), Euphorbia (Cylindrical)**

(5) **Offset** – Pistia, Eichhornia

(6) **Sucker** – Banana, Pineapple, Chrysanthemum

LEAF

Leaves originate from shoot apical meristem and are arranged in an acropetal manner.

The leaf is attached to the stem by leaf base and may bear two lateral small leaf like structures called stipules.

Swollen leaf bases are called pulvinus. e.g. Some leguminous plants.

Venation – Arrangement of veins and veinlets in the lamina of leaf its termed as venation

VENATION

Reticulate
Veinlets form network
(Dicots)

Parallel
Vein run parallel to each other
(Monocots)

TYPES OF LEAVES

Simple
Incision do not touch the mid rib

Compound
Incisions reach up to the mid rib and breaking it into leaf lets

- **Pinnately**
  Leaflets are Present on the rachis
  (Neem)
- **Palmately**
  Leaf lets are attached at the tip of Petiole
  (Silk cotton)

Phyllotaxy (Arrangement of leaves on stem or brach)

Alternate
Single leaf arises at each node
(China rose, mustard, Sunflower)

Opposite
A pair of leaves arise at each node
(Calotropis, Guava)

Whorled
More than two leaves arise at each node
(Alstonia)

Modification of leaves :

(i) **Tendril** – for climbing (Pea)
(ii) **Spine** – For defence (Cacti)
(iii) **Food storage** – Onion, Garlic
(iv) **Petiole Performs photosynthesis** - Australian acacia
(v) **To trap the insect** – Pitcher plant, Venus fly trap.

INFLORESCENCE

(Arrangement of flowers on the floral axis)

Racemose
main axis continues to grow flowers are borne in an acropetal manner

Cymose
main axis terminates in a flower, flowers are born in basipetal manner

FLOWERS

- Swollen end of pedicel is called thalamus.
- Bisexual flower (Flower has both stamen and carpel)
- Unisexual flower (Flower having either stamen or carpel)

SYMMETRY

Actionomorphic (Radial)
Eg- Mustard, Datura, Chilli

Zygomorphic (Bilateral)
Eg- Pea, Gulmohur, Bean, Cassia

Asymmetric (Irregular)
Eg- Canna

Types of flower on the basis of Position of ovary

- **Hypogynous** (ovary superior)
  Eg- Mustard, Chinarose, Brinjal
- **Perigynous** (ovary half inferior)
  Eg- Plum, Rose, Peach
- **Epigynous** (ovary inferior)
  Eg-Guava, Cucumber
  Ray florets of sunflower

Calyx

- Gamosepalous (Sepals united)
- Polysepalous (sepals free)

Corolla

- Gamopetalous (Petals united)
- Polypetalous (Petals free)

AESTIVATION

Mode of arrangement of sepals or petals in floral bud with respect to the other members of the same whorl.

TYPE OF AESTIVATION

- **Valvate** (Calotropis)
- **Twisted** (China rose, Lady's Finger, Cotton)
- **Imbricate** (Cassia, Gulmohur)
- **Vexillary** or **Papilionaceous** (Pea, Bean)

ANDROECIUM

(i) **Epipetalous** (Stamens are attached to the petals) Eg– Brinjal

(ii) **Epiphyllous** (Stamens are attached to the perianth) Eg – Lily

(iii) **Polyandrous** (Stamens remain free)

(iv) **Monoadelphous** (Stamens united into one bundles) Eg- China rose

(v) **Diadelphous** (Stamens united into two bundles) Eg- Pea

(vi) **Polyadelophous** (Stamens united into more than two bundles) Eg- **Citrus**

(vii) **Variation** in the length of filaments within flower eg. Salvia, Mustard.

(viii) Sterile stamen is called staminode.

PLACENTATION

Arangement of ovules within the ovary

- **Marginal**
  Pea
- **Parietal**
  Mustard
  Argemone
- **Axile**
  China rose
  Tomato
  Lemon
- **Free central**
  Dianthus
  Primrose
- **Basal**
  Sunflower
  Marigold

GYNOECIUM

Apocarpous - eg. Rose, Lotus, michelia.

Syncarpous - eg. Mustard, Tomato

FRUIT

○ Mature or ripened ovary is called fruit. If fruit is formed without fertilisation of ovary is called parthenocarpic fruit.

○ Drupe fruits eg. Mango (Mesocarp edible), Coconut (Mesocarp fiberous)

ANATOMY OF FLOWERING PLANTS

- Axillary bud is derived from shoot apical meristem.
- Both apical meristem and intercalary meristem are primary meristem, because they appear early in life of a plant and contribute to the formation of the primary plant body.
- Lateral meristems are cylindrical.
- Intrafascicular cambium is an example of primary lateral meristem.
- Interfascicular cambium and cork cambium (phellogen) are examples of secondary lateral meristem.
- In the dicot stem, vascular cambium is partly primary and partly secondary in origin.
- In the dicot root, vascular cambium is completely secondary in origin.
- Parenchymatous cells are generally isodiametric.
- Collenchymatous cells are much thickened at the corners, due to deposition of pectin, cellulose and hemicellulose
- Collenchyma is present below epidermis either as a homogenous layer or in patches in herbaceous dicotyledonae stem.
- Cell walls of sclerenchymatous cells are thick and lignified.
- Sclereids are commonly found in the fruit wall of nuts, pulp of fruits like guava, pear & sapota, seed coats of legumes and leaves of tea.
- Tracheids are unicellular, whereas vessels are multicellular.
- Vessel is a long cylindrical tube-like structure made up of many cells called vessel elements.
- Xylem fibres have highly thickened walls and obliterated central lumens.
- The radial conduction of water takes place by the ray parenchymatous cells.
- In stems, the primary xylem is endarch, whereas in roots, the primary xylem is exarch.
- Gymnosperms have albuminous cells and sieve cells. They lack sieve tube and companion cells.
- The companion cells are specialised parenchymatous cells, which are closely associated with sieve tube elements.
- The companion cells help in maintaining the pressure gradient in the sieve tubes.
- Phloem parenchyma is absent in most of the monocolyledonae.
- Phloem fibres (Bast fibres) are generally absent in primary phloem.
- Enucleate condition is found in mature sieve tube element and in mature vessel element.
- Protophloem has narrow sieve tubes, whereas metaphloem has bigger sieve tubes.
- Jute, flax and hemp fibres are used commercially.
- Tissue systems are of three types on the basis of their structure, location and function.
- Epidermal cells are parenchymatous.
- Cuticle is absent in roots.
- The stomatal aperture, guard cells and surrounding subsidiary cells are together called stomatal apparatus.
- The root hairs are unicellular elongations of epidermal cells.
- The trichomes in the shoot system are usually multicellular.
- The ground tissue system consists of parenchyma, collenchyma and sclerenchyma.

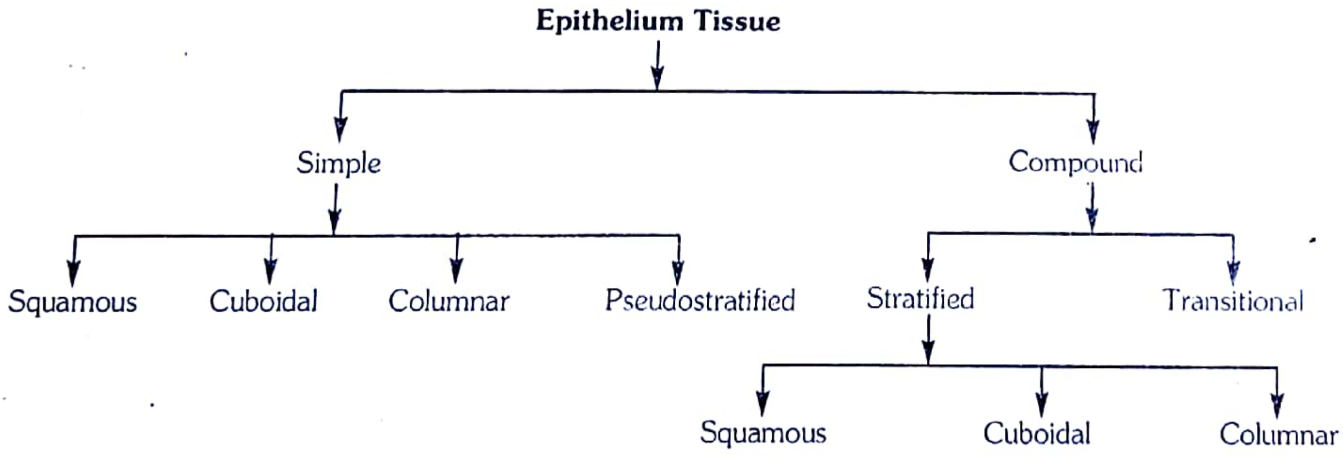
- Radial vascular bundles are found in roots.
- Endodermal cells of roots are barrel-shaped having Casparian strips on radial and tangential walls. These strips are of a waxy-material-suberin.
- In dicot root, pith is small or inconspicous, whereas in monocots roots pith is large and well developed.
- In roots conjunctive tissue is present between the xylem and the phloem. It is made up of parenchyma.
- Dicot roots are usually diarch to Tetrarch (Rerely hexarch), whereas monocot roots are usually polyarch.
- In dicotyledonous stem, endodermis is called starch sheath.
- In dicot stem, hypodermis is collenchymatous, whereas in monocot stem hypodermis is sclerenchymatous.
- In dicot stem (for ex. sunflower stem) pericycle is present above the phloem in the form of semi-lunar patches of sclerencyhyma.
- In dicot stem, vascular bundles are arranged in a ring, whereas in mococot stem vascular bundles are scattered in ground tissue,
- In monocot stem, each vascular bundle is surrounded by sclerenchymatous bundle sheath.
- Type of vascular bundle in dicotyledonae stem ⇒ Conjoint, collateral & open
- Type of vascular bundle in monocotyledonae stem ⇒ Conjoint, collateral & closed
- In a dorsiventral leaf,mesophyll is differentiated into palisade parenchyma (towards adaxial) & spongy parenchyma (towards abaxial).
- In grasses, certain adaxial epidermal cells along the veins modify themselves into large, empty and colourless cells. These cells are called bulliform cells.
- The primary and earlier secondary phloem get gradually crushed due to the continued formation and accumulation of secondary xylem. The primary xylem however remains more or less intact in or around the centre.
- By the activity of vascular cambium ring formation of secondary xylem (towards centre), secondary phloem (towards periphery) and secondary medullary rays (passes through the secondary xylem and the secondary phloem in the radial direction) takes place. Secondary medullary rays are parenchymatous.
- In temperate region, the climatic conditions are not uniform throughout the year.
- In the spring season vascular cambium is very active, whereas in winter it is less active.
- The cork is impervious to water, due to suberin deposition in the cell wall.
- Phellem (cork). Phellogen (cork cambium) and phelloderm (secondary cortex) are collectively known as periderm.
- Complimentary cells of lenticels are derived from phellogen.
- Bark is a non-technical term that refers to all tissues exterior to the vascular cambium, therefore including secondary phloem.
- Secondary phloem and periderm are included in bark.
- Lenticels occur in most woody trees.
- Lenticels are lens shaped openings.
- In the begining vascular cambium is wavy, which later becomes circular in the dicot root.

ANIMAL TISSUE

- A tissue is defined as group of cells along with intercellular substance having similar origin and performing similar function.

EPITHELIUM TISSUE

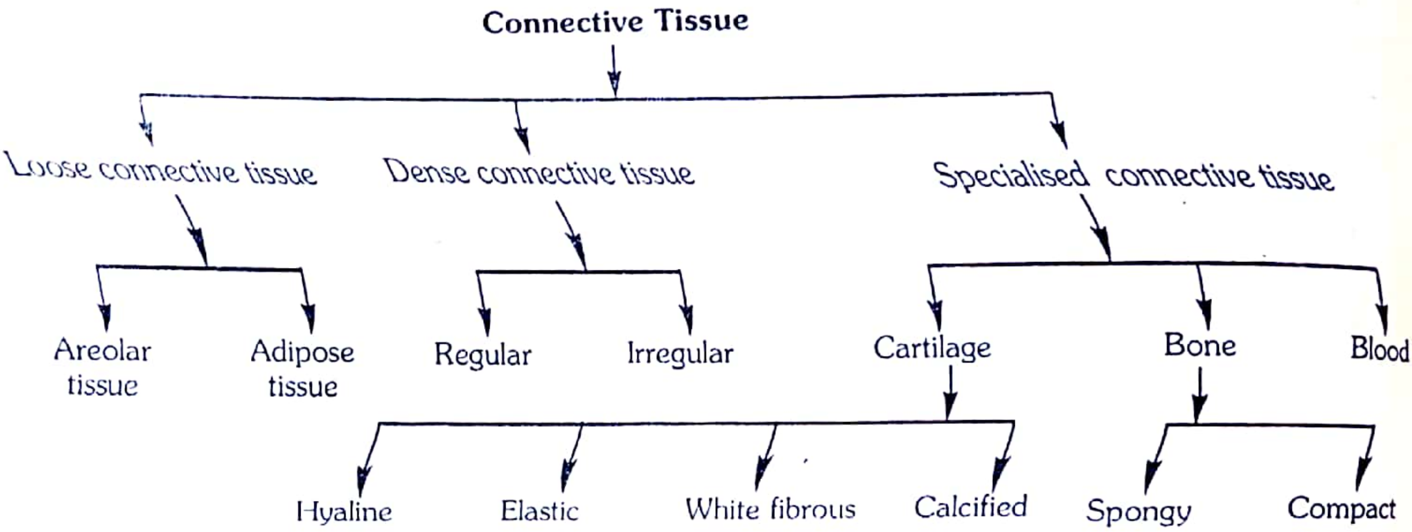
- Epithelium tissue has a free surface, which faces either a body fluid or the out side environment.
- Epithelium is of two type : simple and compound epithelium.
- Simple epithelium is made up of a single layer of cells and functions as a lining for body cavities, ducts and tubes. The compound epithelium consists of two or more cell layers and has protective function.
- Simple squamous epithelium is made of a single layer of flattened cell with irregular boundaries. Found in blood vessel and inner lining on lungs and are involved in forming a diffusion boudary.
- The cuboidal epithelium is commonly found in ducts of glands and tubular part of nephrons and its main function is secretion and absorption.
- The columnar epithelium is made up of pillar shaped cells in which nucleus is located at the base. When free surface has microvilli, found in the lining of stomach and intestine.
- When their free surface has cilia they are called as ciliated epithelium, found in the lining of bronchioles and fallopian tubes.
- Compound epithelium has a limited role in secretion and absorption. Their main function is to provide protection against chemical and mechanical stresses. They cover the moist surface of buccal cavity, pharynx, inner lining of ducts of salivary gland and of pancreatic ducts.
- Some of columnar or cuboidal cells get specialised for secretion and are called as glandular epithelium. They are mainly of two types, unicellular (goblet cells) and multicellular (salivary glands)
- On the basis of mode of pouring their secretion glands are exocrine and endocrine.
- Three types of cell junctions are found in epithelium : Tight junction (help to stop substances from leaking across a tissue) Adhering junctions (perform cementing - to keep neighbouring cells together) Gap junction (for rapid transfer of ions, small molecules and some times big molecules)



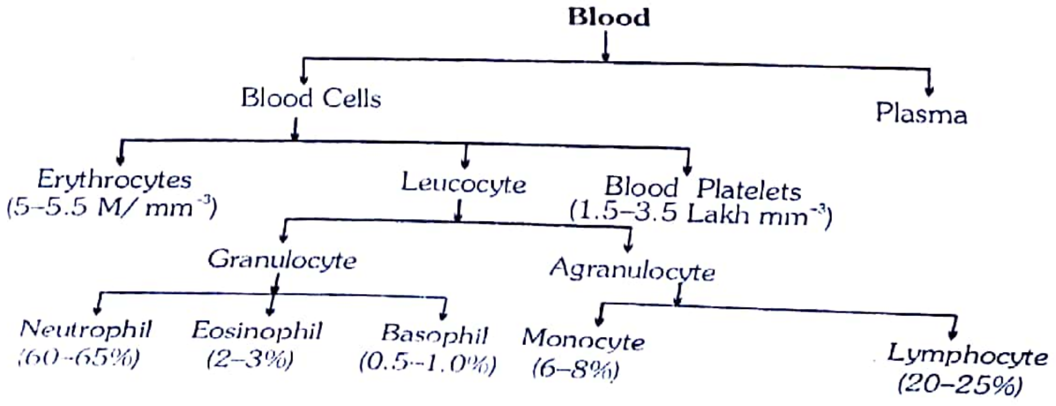
CONNECTIVE TISSUE

- Connective tissue are most abundant and widely distributed in the body.
- Their special function are linking and supporting other tissues/organs of the body.
- In all connective tissues except blood the cells secret fibres like collagen, elastic and reticular.
- These cells also secrete modified polysaccharides which accumulate between cells and fibres which acts as matrix (ground substance).

- Connective tissues are classified into three types
  - (i) Loose connective tissue.
  - (ii) Dense connective tissue.
  - (iii) Specialised connective tissue.
- Loose connective tissue consists of Areolar and Adipose tissue, present beneath the skin.
- In Dense connective tissue fibres and fibroblasts are compactly packed.
- Dence connective can be regular namely Tendon and Ligament where as irregular are oriented differently in the skin.

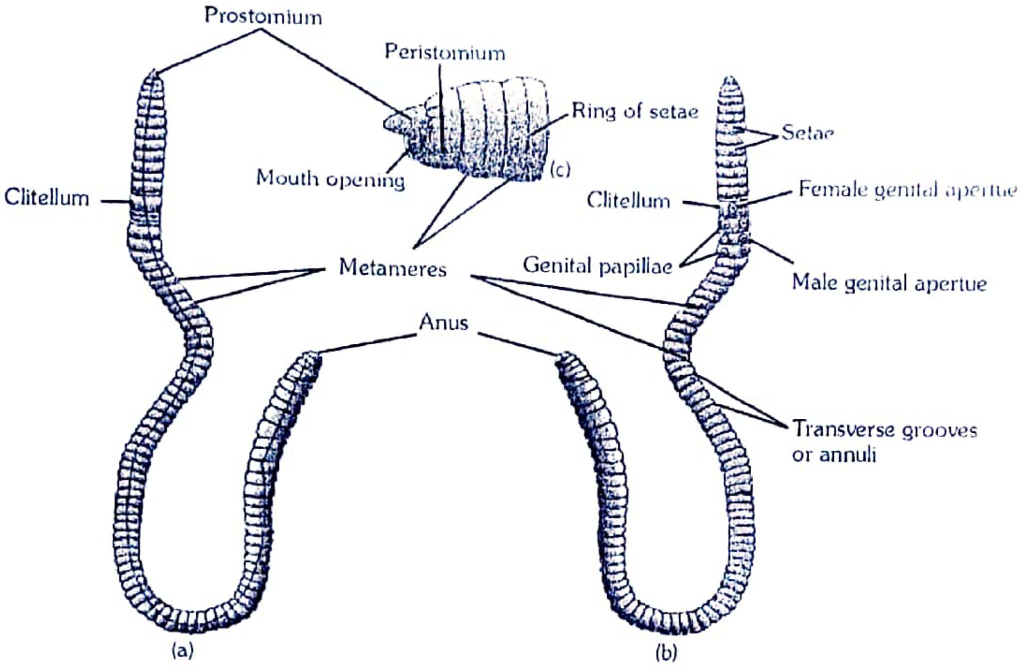

Connective Tissue
Loose connective tissue
Dense connective tissue
Specialised connective tissue
Areolar tissue
Adipose tissue
Regular
Irregular
Cartilage
Bone
Blood
Hyaline
Elastic
White fibrous
Calcified
Spongy
Compact

- In cartilage intercellular material is solid and pliable e.g.– tip of nose, ear pinna etc.
- Bone have a hard and non-pliable ground substance rich in calcium salt. Bone cells (osteocytes) are pres in the Lacunae. The bone marrow in some bone is the site of production of blood cells.


Blood
Blood Cells
Plasma
Erythrocytes (5–5.5 M/ mm⁻³)
Leucocyte
Blood Platelets (1.5–3.5 Lakh mm⁻³)
Granulocyte
Agranulocyte
Neutrophil (60–65%)
Eosinophil (2–3%)
Basophil (0.5–1.0%)
Monocyte (6–8%)
Lymphocyte (20–25%)

- Blood is fluid connective tissue containing plasma, RBC, WBC and platelets. It is main circulating fluid that helps in the transport of various substances.

EARTHWORM (PHERETIMA POSTHUMA)


Prostomium
Peristomium
Ring of setae
Setae
Clitellum
Mouth opening
(c)
Clitellum
Female genital apertue
Metameres
Genital papillae
Male genital apertue
Anus
Transverse grooves or annuli
(a)
(b)

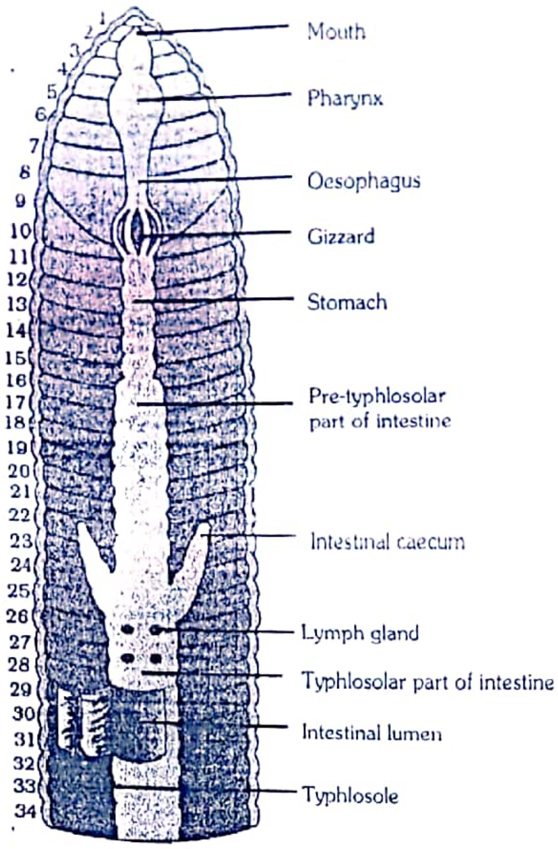
Body of earthworm : (a) dorsal view (b) ventral view (c) lateral view showing mouth opening

- Earthworms have long cylindrical body.
- Body is divided into 100 – 120 segments.
- Anterior end consists of the mouth and the *Prostomium.* A lobe which serves as a covering for the mouth and as a wedge to froce open cracks in the soil into which the earthworm may crawl.
- The prostomium is sensory in function.
- The first body segment is called the *peristomium* (buccal segment)
- In a Mature worm, segments 14 – 16 are covered by a prominent dark band of glandular tissue called →clitellum
- 4 Pair of spermathecal apertures are situated on the ventro-lateral sides of the intersegmental grooves in 5th to 9th segments.
- A single female genital pore is present in the mid-ventral line of 14th segment.
- A pair of male genital pores are present on the ventro-lateral sides of the 18th segment.
- Numerous minute pores called nephridio-pores open on the surface of the body.
- In each body segment except the first last and clitellum there are rows of s-shaped setae.
- Setae help in locomotion.

BODY WALL

- Body wall of earthowrm is consits of cuticle, epidermis, muscular layers and coelomic epithelium.
- Epidermis consists of tall, columnar cells of four types:
  (i) Supporting cells (major Part)
  (ii) Glandular cells (Goblet and albumin)
  (iii) Basal cells
  (iv) Sensory cells
- Circular and longitudinal muscle layers are present in the muscle layer they are help in locomotion.

ALIMENTARY CANAL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31
32
33
34
Mouth
Pharynx
Oesophagus
Gizzard
Stomach
Pre-typhlosolar part of intestine
Intestinal caecum
Lymph gland
Typhlosolar part of intestine
Intestinal lumen
Typhlosole

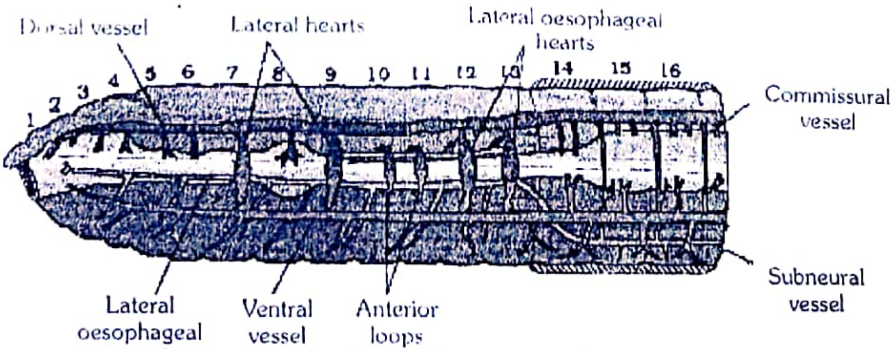
Alimentary canal of earthworm

- Earthworm has a straight alimentary canal, representing a "tube with in a tube Plan"
- Location of different parts of alimentary canal are:

(i) Buccal chamber	(1 – 3 segments)
(ii) Pharynx	(4 – 5 segments)
(iii) Oesophagus	(6 – 7 segments)
(iv) Gizzard	(8 – segment)
(v) Stomach	(9 – 13/14 segment)
(vi) Intestine	(15 to last)

- Mouth present in first segment (Peristomium)
- Mouth open into buccal cavity which leads in to muscular pharynx.
- Roof of pharynx contains pharyngeal glands containing chromophil cell. Secreting mucus and proteases.
- Gizzard is a thick muscular organ, cavity lined by tough cuticle for grinding.
- Wall of stomach contains 'Calciferous glands' the secretion of which neutralizes the acidity of soil.
- Intestin has three regions:
  (i) Pretyphlosolar region,
  (ii) Typhlosolar region and
  (iii) Post-typhlosolar region.
- Typhlosole is a highly glandular, vascular longitudinal ridge increasing The are for absorption of digested food
- Earthworm are omnivorous, undigested particles as faeces are called as '***Casting***'.
- Casting Improve the fertility of soil.

BLOOD VASCULAR SYSTEM


Dorsal vessel
Lateral hearts
Lateral oesophageal hearts
1
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14
15
16
Commissural vessel
Subneural vessel
Lateral oesophageal vessel
Ventral vessel
Anterior loops

Closed circulatory system

- Blood vascular system of earthworm is closed type.
- Blood is red in colour, respiratory pigment haemoglobin is dissolved in the blood plasma.
- Blood vascular system is different in first 13 segments as regards to number arrangement and nature of blood vessels.
- The Main longitudinal vessel are:
  - (i) Dorsal blood vessel
  - (ii) ventral blood vessel
  - (iii) Lateral oesophageal vessels (Paired)
  - (iv) subneural vessel and
  - (v) supraoesephageal vessel (smallest)
- Important transverse vessels in first 13 segments are:
  - (i) Lateral hearts (Segments 7 and 9)
  - (ii) Anterior loops (Segments 10 and 11)
  - (iii) Lateral oesophageal hearts (segments 12 and 13)

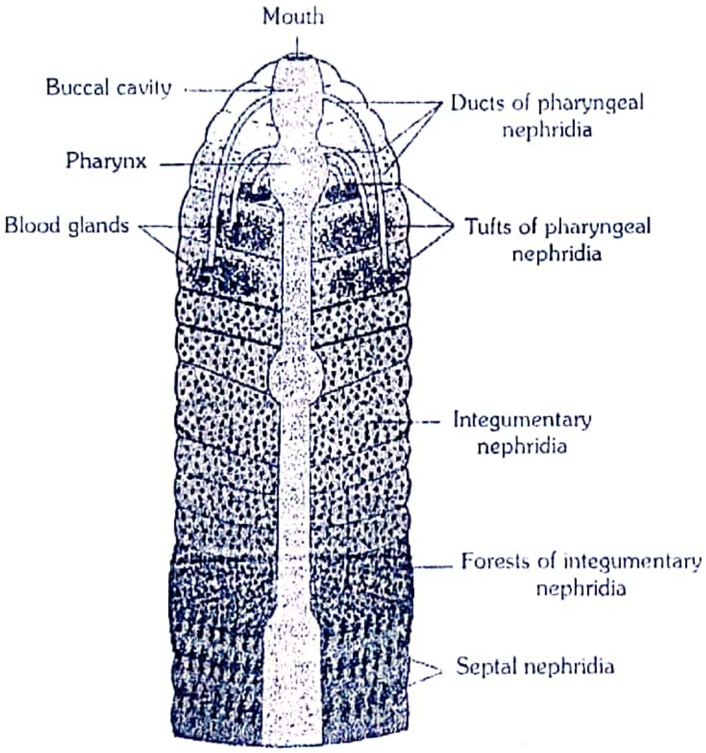
Blood Glands:

- Blood glands are located in the segments 4, 5 and 6 above the pharyngeal mass.
- Blood glands serve for the manufacture of blood corpuscles and haemoglobin.

RESPIRATORY SYSTEM

- Earthworm respires but has no respiratory organs, exchange of gases takes place through moist skin.

EXCRETORY SYSTEM


Mouth
Buccal cavity
Pharynx
Blood glands
Ducts of pharyngeal nephridia
Tufts of pharyngeal nephridia
Integumentary nephridia
Forests of integumentary nephridia
Septal nephridia

Nephridial system in earthworm

- Excretory organs of earthworm are segmental nephridia of ectodermal in origion, analogns to vertebrate kidney.
- Septal nephridia are enteronephric finally excretory products are poured into intestine.
- Enteronephric condition is an adaptation for the conservation of water.
- The nephridia extract water and excretory substances from both blood and coelmic fluid by ultrafiltration.
- Excretory products of earthworm are urea (about 50%) ammonia (about 40%) and traces of creatitine.
- Earthworms are mainly ureotelic.

NERVOUS SYSTEM

- Earthworms has a well developed nervous system. It has a brain but no head.
- Brain lies above Pharynx, made up of a pair of suprapharyngeal (cerebral) ganglia.
- A solid ventral nerve cord arises from subpharyngeal ganglion.
- Neurons in earthworm are motor, sensory and adjustor type.

SENSE ORGANS

- Sense organs in earthworm are quite simple three types are:

  (i) Epidermal receptor (tangoreceptors)

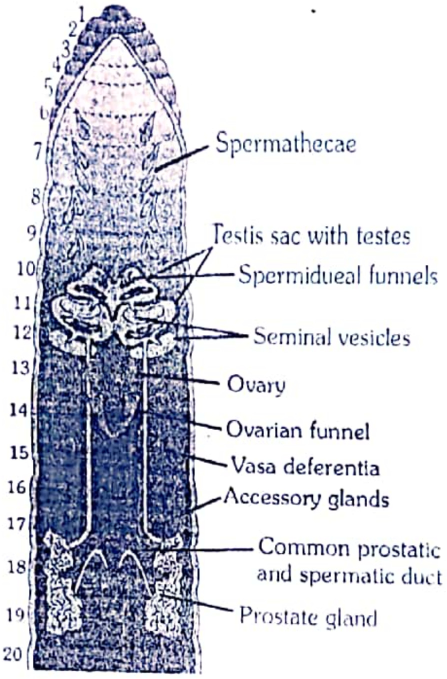
  (ii) Buccal receptors (gustatory and olfactory)

  (iii) Photoreceptors

  On the surface of skin on dorsal side.

- Earthworm has no eyes, photoreceptors are used to judge intensity and duration of light, donot have the capacity of vision.

REPRODUCTIVE SYSTEM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Spermathecae
Testis sac with testes
Spermidueal funnels
Seminal vesicles
Ovary
Ovarian funnel
Vasa deferentia
Accessory glands
Common prostatic and spermatic duct
Prostate gland

Reproductive system of earthworm

- Earthworms do not reproduce asexually.
- Earthworms are monoecious or hermaphrodites.
- They are protandrous, there is no self-fertilization.
- **Male Organs :**

  (i) Testes two pairs → (Segments 10 and 11)

  (ii) Seminal vesicles → (Segments 11 and 12)

  (iii) Accessory glands → (Segments 17 and 19)

  (iv) Genital papillae → (Segments 17 and 19)

  (v) Male genital apertures → (Segments 18)

  (vi) Prostate gland → (Segments 17 – 20)

- **Female Organs :**

  (i) Ovary one pair → (Segment 13)

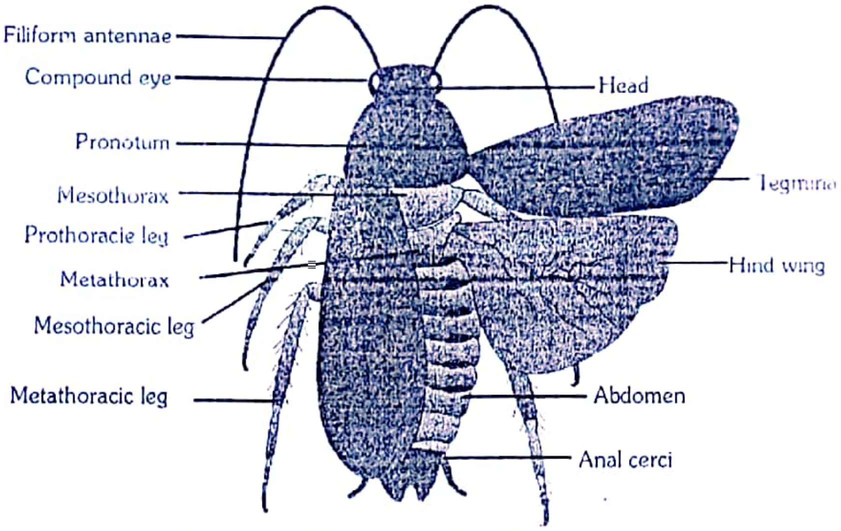
  (ii) Female genital Pore → (Segment 14)

  (iii) Spermatheca 4 pairs → (Segments 6, 7, 8, 9)

- Spermatheca are used to store and transfer of sperms after copulation.
- Cocoons are formed by glandular *clitellum*.
- Fertilization is external and occurs in cocoon.
- Metamorphosis does not occur in earthworm.

COCKROACH (PERIPLANETA AMERICANA)

[External features of cockroach]

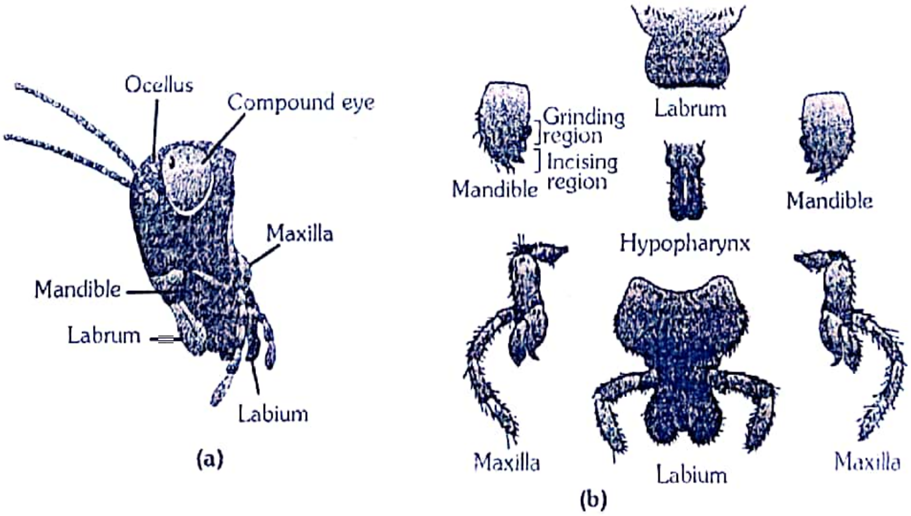

Filiform antennae
Compound eye
Pronotum
Mesothorax
Prothoracic leg
Metathorax
Mesothoracic leg
Metathoracic leg
Head
Tegmina
Hind wing
Abdomen
Anal cerci

External features of cockroach

- Cockroaches belong to the class insecta of the phylum arthropoda.
- Their size ranges from 1/4 inches to 3 inches (0.6 – 7.6cm) and have long antenna, legs and flat extension of the upper body wall that conceals head.

MORPHOLOGY

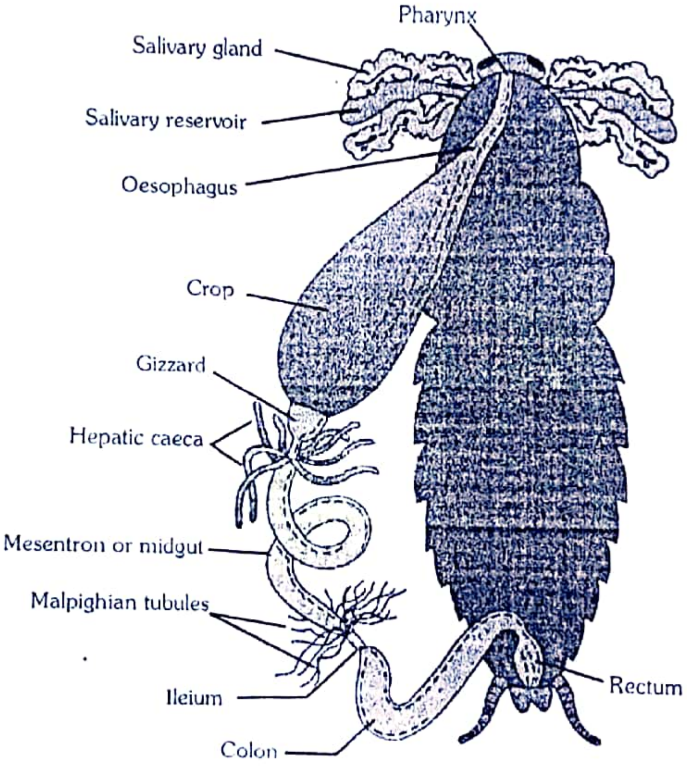
- Cockroach are cursorial (running) and nocturnal.
- The body of the cockroach is segmented and divisible into three distinct regions-head, thorax and abdomen.
- Body is covered with chitinous exo skeleton of scalerites.
- Head is derived by the fusion of six embryonic segments.
- Head bears a pair of long antennae a pair of ocelli or fenestrae and a pair of compound eyes.
- Antennae have sensory receptors that help in monitoring the environment.
- The thorax consists of three segments; Prothorax, Mesothorax and metathorax.
- Thorax bears three pairs of jointed appendages and two pairs of wings on mesothorax and metathorax.
- Abdomen is the largest and broadest part consisting of ten segments (11 segments in embryo) without appendages


Ocellus
Compound eye
Maxilla
Mandible
Labrum
Labium
(a)
Grinding region
Incising region
Mandible
Labrum
Mandible
Hypopharynx
Maxilla
Labium
Maxilla
(b)

Head region of cockroach : (a) parts of head region (b) mouth parts

- Mouthparts of cockroach are mandibulate type or bitting and chewing type.
- Mouth parts consitsts of labrum (upper lip), labium (lower lip), maxillae (segmented and resemble to a leg), mandibles and hypo pharynx (tongue).
- The main structures of mastication (chewing) are mandibles which are short with teeth.
- Leg of cockroach is five segmented, these segments are, coxa, trochanter, femur, tibia and tarsus.
- The most swollen segment in the leg of cockroach is coxa.
- The longest segment in the leg of cockroach is tibia.
- Anal cerci, a pair of many jointed structure are present on the tergite of 10th segment in male and female cockroach.
- Anal styles, a pair of small, spine-like unjointed structures are present on sternite of 9th segment in males only.
- Anal cerci bear minute sensory hairs which are sensitive to sound and other vibrations.
- Cockroach has two pairs of wings.
- The first pair (mesothoracic) are thick hard and leathery protective in function called tegmina (elytra).
- Second Pair (metathoracic) are thin, soft and membranous.

ANATOMY

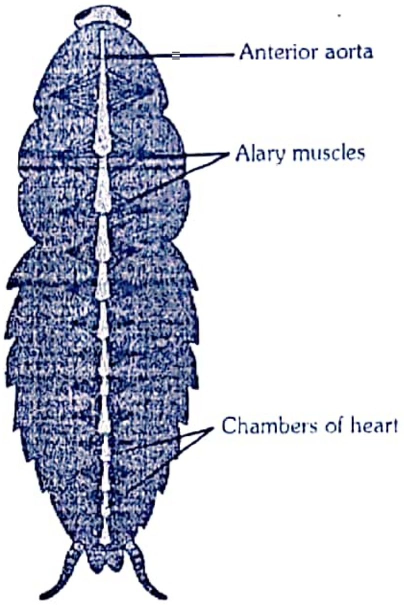


Alimentary canal of cockroach

Digestive System:

- The alimentary canal is long and coiled, divided into three regions: foregut, midgut and hindgut.
- Foregut (stomodaeum) is differentiated into five parts: buccal chamber, pharynx, oesophagus, crop and gizzard.
- Gizzard is muscular and internally provided with six cuticular teeth which crush the food.
- Midgut (mesenteron) is short, tubular lined with glandular endoderm.
- At anterior end of mesentron there are eigth blind glandular hepatic caecae which secrete digestive enzymes.
- Hindgut (proctodaeum) comprises ileum, colon and rectum.
- The wall of rectum is provided with six rectal papillae, which help in the absorption of water and salts.
- Cockroach is omnivorous: it feed on all sorts of organic debris.
- The digestive enzymes of saliva are mainly Zymase and amylase.
- Most of the nutrients of food are digested in the crop.
- Absorption of digested food takes place in mesenteron.

CIRCULATORY SYSTEM



Open circulatory system of cockroach

- Circulatory system of cockroach is open type.
- The blood of cockroach flows through haemocoelic system.
- Haemocoel is divided into a dorsal pericardial sinus, a middle perivisceral sinus and a ventral perineural sinus by two perforated diaphragms.
- The heart is longitudinally beaded with 13 chambers perforated by ostia having valves.
- The blood circulation is maintained by 13 pairs of wing shaped involuntary alary muscles
- Heart of cockroach is neurogenic.

RESPIRATORY SYSTEM

- Respiratory system of cockroach consists of tracheal system.
- The tracheal system opens outside by ten pairs of spiracles (two pairs thoracic and eight pairs of abdominal). The spiracles are with valves.
- The first thoracic and first abdominal spiracles remain open all the times.
- Ventilation of tracheal system is by alternate contraction and relaxation of abdomen.

EXCRETORY SYSTEM

- Excretory organs of cockroach are malpighian tubules open at the junction of midgut and hindgut (ileum).
- Malpighian tubules absorb excretory substances from haemolymph and fat bodies and pass into the proctodaeum
- Malpighian tubules are concerned with homeostasis osmoregulation and excretion.
- Excretory products of cockroach are uric acid and urates of sodium and potassium so they are uricotelic.
- Fat body of cockroach contains mainly four types of cell. Trophocytes mycetocytes oenocytes and urate cells
- Fat body of cockroach is functionally **analogous to liver of vertebrates.**

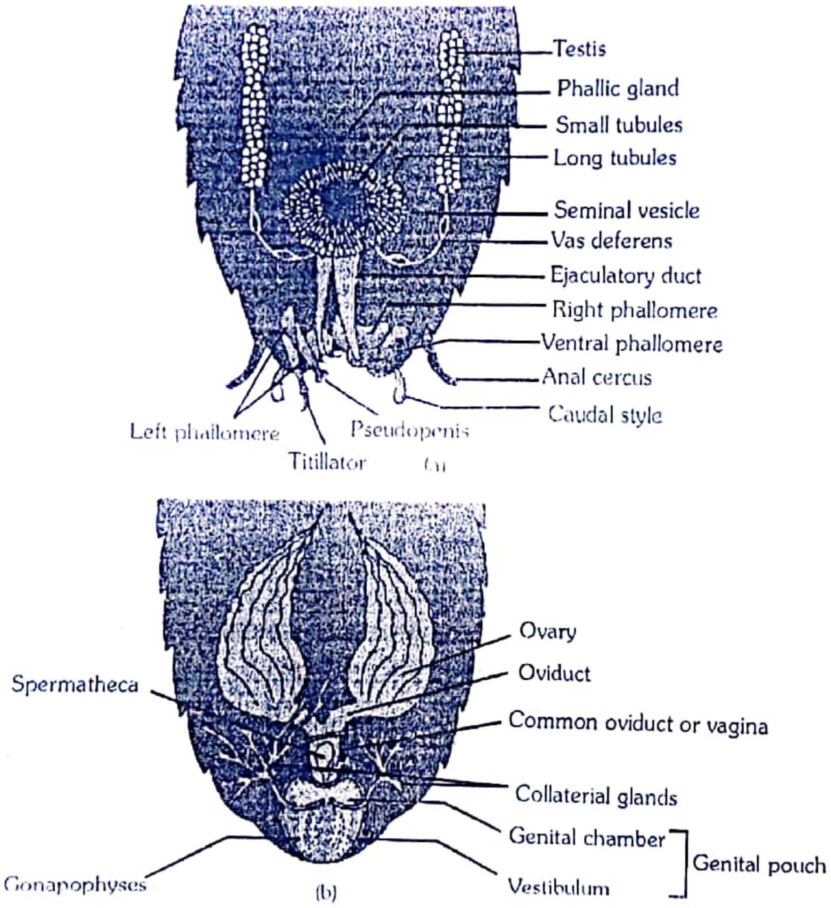
NERVOUS SYSTEM

- Cockroach has a well developed nervous system with central, peripheral and sympathetic (autonomous) nervous system.
- Central nervous system consists of cerebral or supraoesophageal ganglion (brain), suboesophageal ganglion paired circumoesophageal connective double ventral nerve cord with three thoracic and six abdominal ganglion.
- Nerves given off to all parts of the body constitute the peripheral nervous system.
- Autonomic or stomatogastric nervous system include five ganglia namely frontal (pharynx),hypocerebral (oesophagus), visceral or ingluvial [crop] and proventricular (gizzard).

ENDOCRINE SYSTEM

- Endocrine system of cockroach consists of corpora allata, corpora cardiaca and prothoracic gland.
- Intercerebral glands in brain secrete the brain hormone.
- Brain hormone stimulates the prothoracic glands to secrete a moulting hormone called ecdysone.
- Corpora allata are neurosecretory and secrete juvenile hormone or neotinin.
- Sense organs in cockroach are: Photoreceptors (compound and simple eyes), thigmoreceptors (antenna chemoreceptors (on maxillary and labial palps, labium and hypopharyns) and auditory receptors on anal cer
- Each compound eye of cockroach is composed of about 2000 visual units called ommatidia.
- There are two types of vision in insects mosaic vision or appostion image during day time and superpositio or dull image in dim light.
- But in cockroach, pigment sheath of ommatidia is non-contractile so capable of only mosaic vision even durin night.

REPRODUCTIVE SYSTEM


Testis
Phallic gland
Small tubules
Long tubules
Seminal vesicle
Vas deferens
Ejaculatory duct
Right phallomere
Ventral phallomere
Anal cercus
Caudal style
Left phallomere
Pseudopenis
Titillator
(a)
Ovary
Oviduct
Spermatheca
Common oviduct or vagina
Collaterial glands
Genital chamber
Vestibulum
Genital pouch
Gonapophyses
(b)

Reproductive system of cockroach : (a) male (b) female

Male reproductive system

- In cockroach, sexes are separate so dioecious.
- **Male organs** consist of testes vasadifferentia, ejaculatory duct, mushroom or utricular gland, phallic or conglobate gland and male gonapophyses.
- Testes of cockroach are located in the abdominal segments 4, 5 and 6
- Mushroom glandconsists of two types of tubules, the

(i) long slender tubules, the utriculi majores or peripheral tubules,and

(ii) Short tubules, the utriculi breviores, making up of the major part of the gland.

- small seminal vesicles are also found associated with mushroom gland.
- All sperms of a seminal vesicle are glued together into a large bundle called spermatophore.
- Spermatophore has three-layered wall: Inner layer secreted by utriculi majores; middle layer secreted by ejaculatory duct and outer layer secreted by phallic gland.

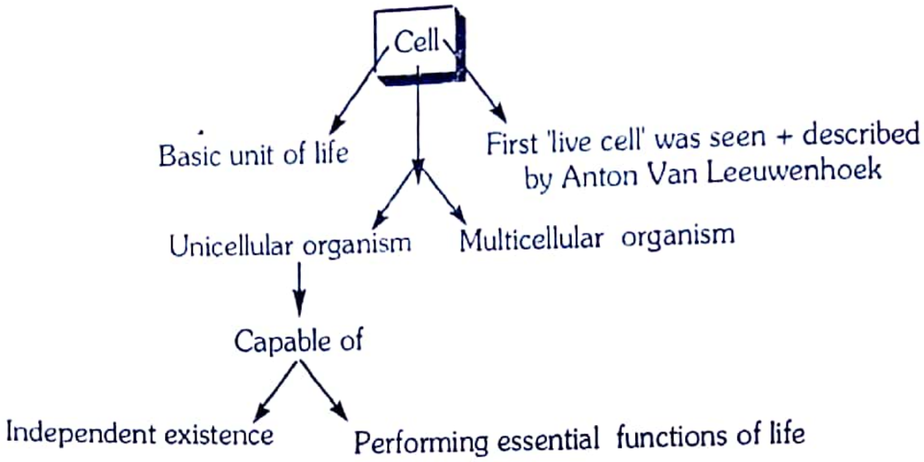
Female reproductive system

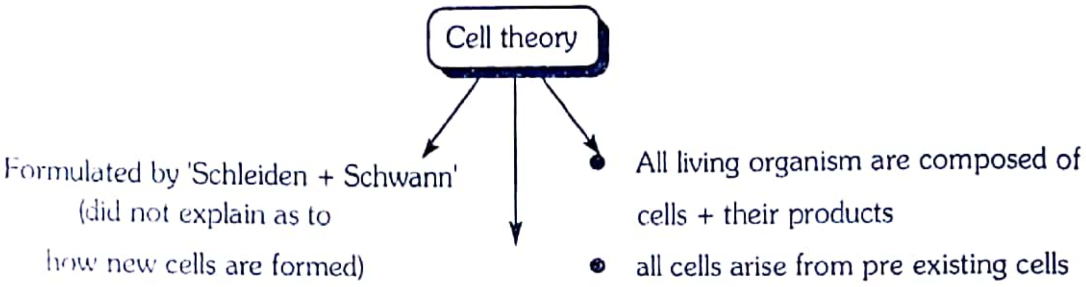
- Female organs consist of ovaries,oviducts, Vagina,genital chamber, spermathecae,colleterial gland and female gonapophyses.
- Ovaries of cockroach are located in the abdominal segments 2 to 6.
- Each ovary consists of eight ovarioles.
- Two oviducts from each side open into a common oviduct or vagina which open into genital chamber by female genital pore.
- A pair of spermathecae are present near female genital pore.

DEVELOPMENT

- The egg of cockroach is centrolecithal type yolk being in the centre.
- Ootheca of cockroach contains sixteen fertilized eggs.
- Ootheca of cockroach is formed of a protein secreted by colleterial glands.
- Nymph of cockroach emerges out form Ootheca
- A nymph resembles the adult in general structure but lacks the wings and mature reproductive organs
- Metamorphosis in cockroach is incomplete or paurometabolus type.
- Metamorphosis is regulated by two hormones ecdysone. Secreted by prothoracic glands and juvenile hormone secreted by corpora allata.

CELL : THE UNIT OF LIFE


Cell
Basic unit of life
First 'live cell' was seen + described by Anton Van Leeuwenhoek
Unicellular organism
Multicellular organism
Capable of
Independent existence
Performing essential functions of life

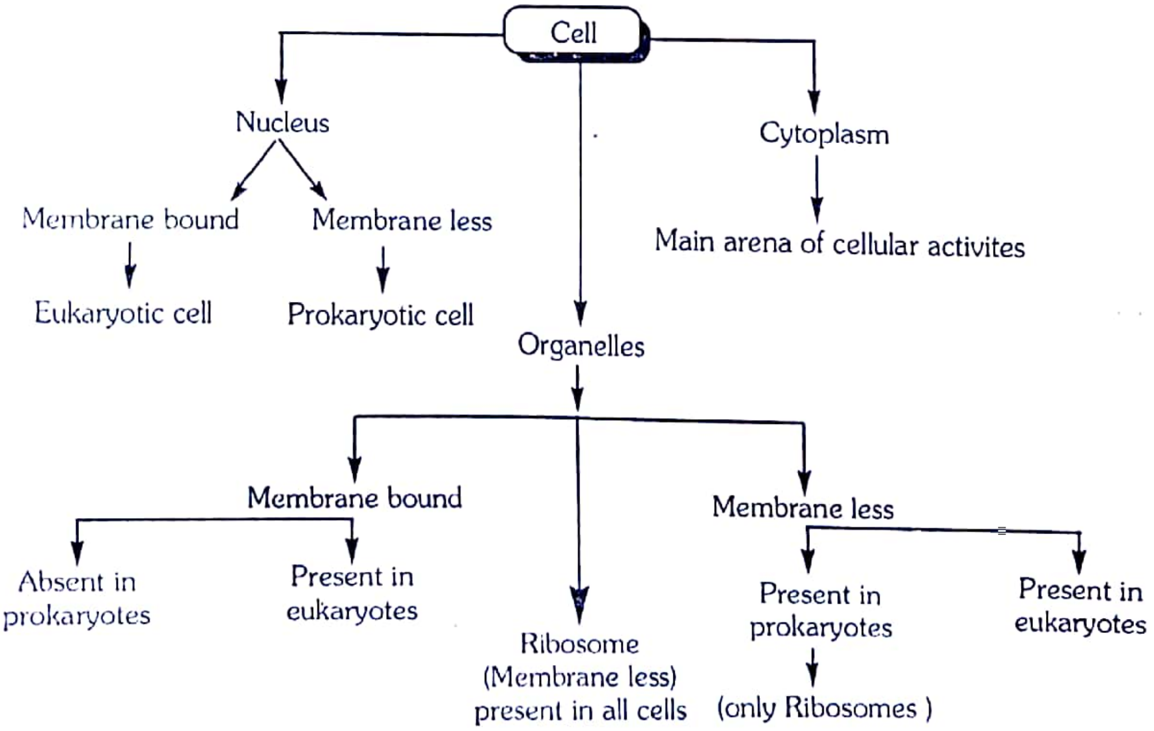

Cell theory
Formulated by 'Schleiden + Schwann' (did not explain as to how new cells are formed)
● All living organism are composed of cells + their products
● all cells arise from pre existing cells

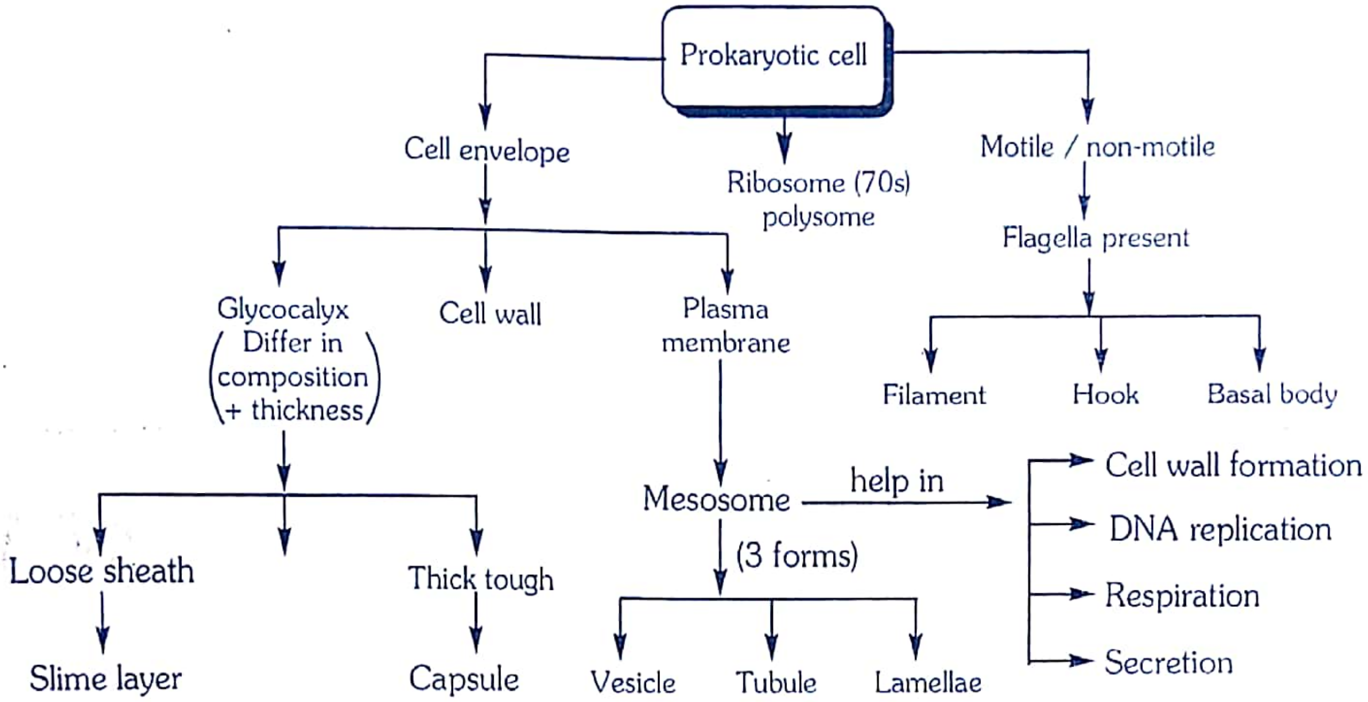
It was explained by Rudolf Virchow,

he proposed **"Omnis cellula-e-cellula"**

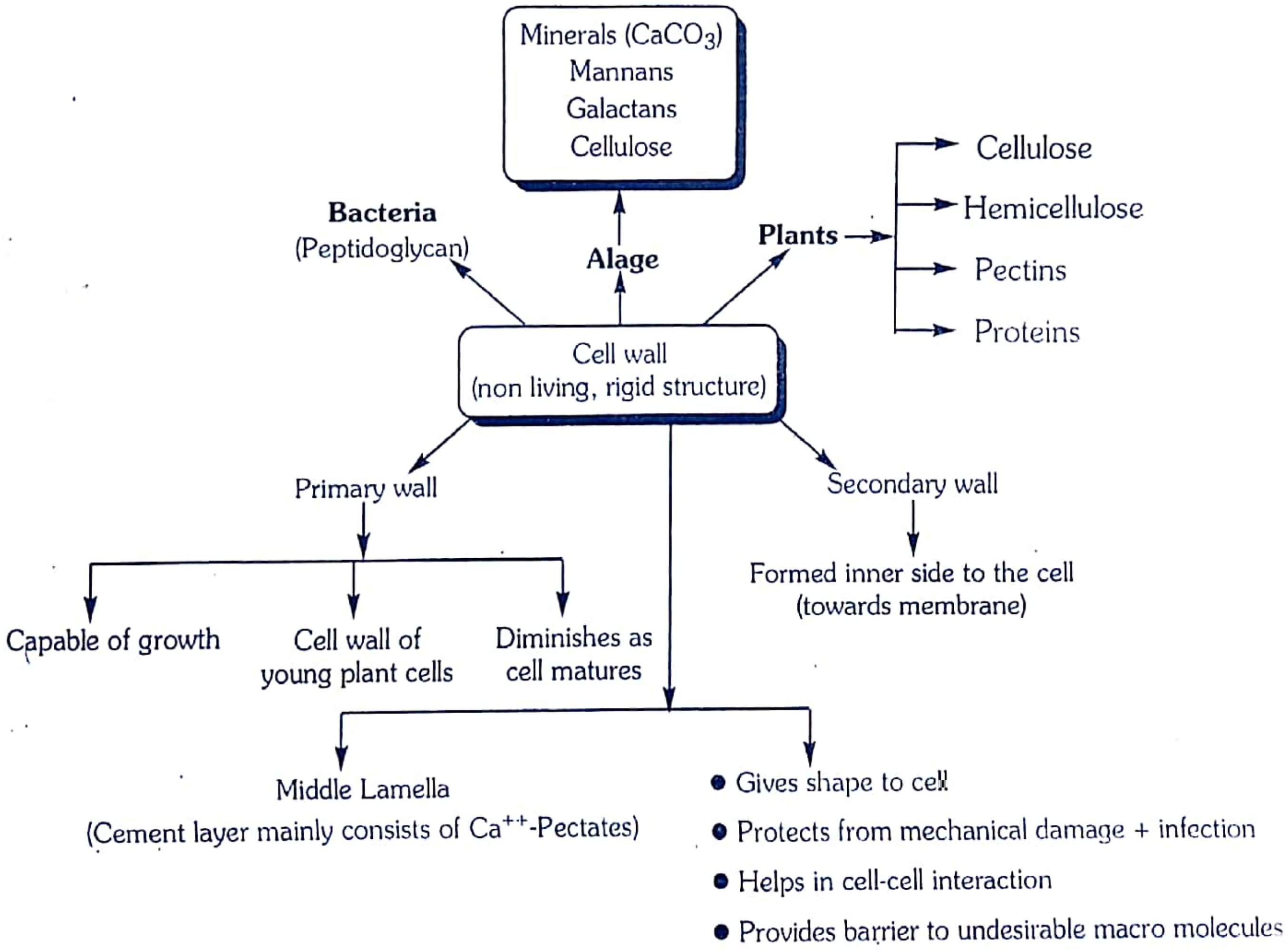
and

Not only modified + gave the final shape to cell theory

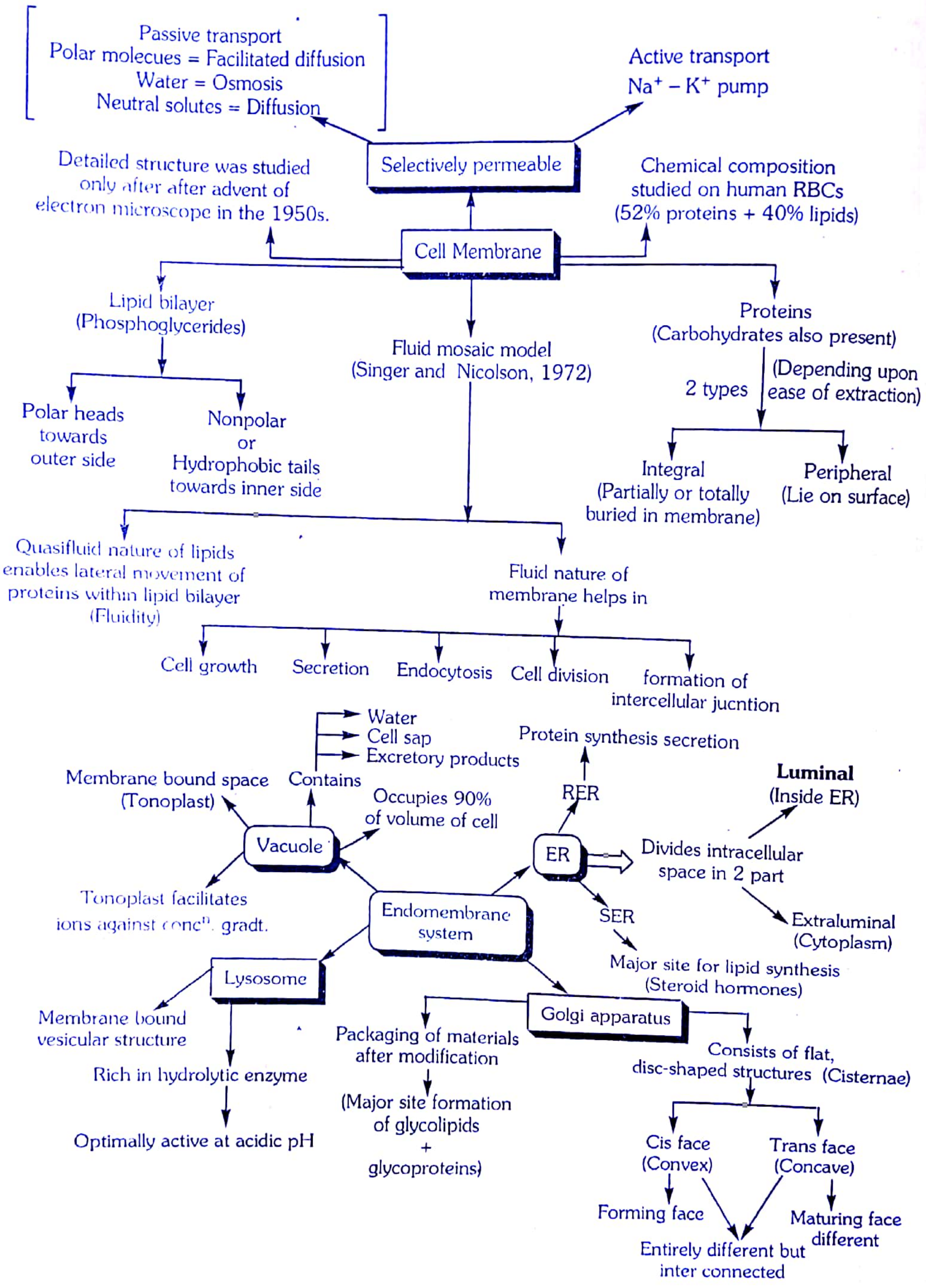

Cell
Nucleus
Membrane bound
Eukaryotic cell
Membrane less
Prokaryotic cell
Cytoplasm
Main arena of cellular activites
Organelles
Membrane bound
Absent in prokaryotes
Present in eukaryotes
Ribosome (Membrane less) present in all cells
Membrane less
Present in prokaryotes
(only Ribosomes)
Present in eukaryotes


Prokaryotic cell
Cell envelope
Ribosome (70s) polysome
Motile / non-motile
Flagella present
Filament
Hook
Basal body
Glycocalyx
Differ in composition + thickness
Cell wall
Plasma membrane
Loose sheath
Slime layer
Thick tough
Capsule
Mesosome
help in
Cell wall formation
DNA replication
Respiration
Secretion
(3 forms)
Vesicle
Tubule
Lamellae

CELL WALL


Minerals ($CaCO_3$)
Mannans
Galactans
Cellulose
Bacteria
(Peptidoglycan)
Alage
Plants
Cellulose
Hemicellulose
Pectins
Proteins
Cell wall
(non living, rigid structure)
Primary wall
Secondary wall
Formed inner side to the cell (towards membrane)
Capable of growth
Cell wall of young plant cells
Diminishes as cell matures
Middle Lamella
(Cement layer mainly consists of Ca^{++}-Pectates)
Gives shape to cell
Protects from mechanical damage + infection
Helps in cell-cell interaction
Provides barrier to undesirable macro molecules

CELL MEMBRANE



Passive transport
Polar molecues = Facilitated diffusion
Water = Osmosis
Neutral solutes = Diffusion

Active transport
Na⁺ – K⁺ pump

Selectively permeable

Detailed structure was studied only after after advent of electron microscope in the 1950s.

Chemical composition studied on human RBCs (52% proteins + 40% lipids)

Cell Membrane

Lipid bilayer (Phosphoglycerides)

Polar heads towards outer side

Nonpolar or Hydrophobic tails towards inner side

Fluid mosaic model (Singer and Nicolson, 1972)

Proteins (Carbohydrates also present)

2 types (Depending upon ease of extraction)

Integral (Partially or totally buried in membrane)

Peripheral (Lie on surface)

Quasifluid nature of lipids enables lateral movement of proteins within lipid bilayer (Fluidity)

Fluid nature of membrane helps in

Cell growth
Secretion
Endocytosis
Cell division
formation of intercellular jucntion

Vacuole

Membrane bound space (Tonoplast)

Contains
Water
Cell sap
Excretory products

Occupies 90% of volume of cell

Tonoplast facilitates ions against concⁿ. gradt.

Endomembrane system

ER

RER
Protein synthesis secretion

SER
Major site for lipid synthesis (Steroid hormones)

Divides intracellular space in 2 part

Luminal (Inside ER)

Extraluminal (Cytoplasm)

Lysosome

Membrane bound vesicular structure

Rich in hydrolytic enzyme

Optimally active at acidic pH

Golgi apparatus

Packaging of materials after modification

(Major site formation of glycolipids + glycoproteins)

Consists of flat, disc-shaped structures (Cisternae)

Cis face (Convex)
Forming face

Trans face (Concave)
Maturing face

Entirely different but inter connected

different

MITOCHONDRIA

⇒ Visible under the microscope only after specific staining.

⇒ Number per cell is variable, **depending on the physiological activity of the cells.**

Mitochondria

- Size
  - → Diameter 0.2 to 1 μm (average 0.5 μm)
  - → Length 1.0 to 4.1 μm
- Shape → Sausage shaped 'or' Cylindrical
- → Double membranous
  - ● Two aqueous compartments
  - ● Outer ⇒ Inter membrane space (peri mitochondiral space)
    Inner ⇒ Matrix
  - ● Outer membrane continuous
  - ● Inner membrane with infolding called Cristae, towards matrix
  - ● Cristae increase surface area
- Matrix
  - → ds Circular DNA
  - → Few RNA molecules
  - → 70s ribosomes
- → Divide by Fission
- Function → Aerobic respiration (Produce ATP)
  So called 'power houses' of the cell.

PLASTIDS

→ On the basis of presence or absence of pigments and types of pigments, plastids are of 3 types.

(i) Leucoplast (ii) Chromoplast (iii) Chloroplast

Leucoplast

- → Amyloplast : Store Carbohydrates (Starch)
  eg. : Potato
- → Elaioplast : Store Oils and Fats
- → Aleuroplast : Store proteins

→ Colourless plastid (Pigments absent)
→ Function - storage of nutrients (Food)

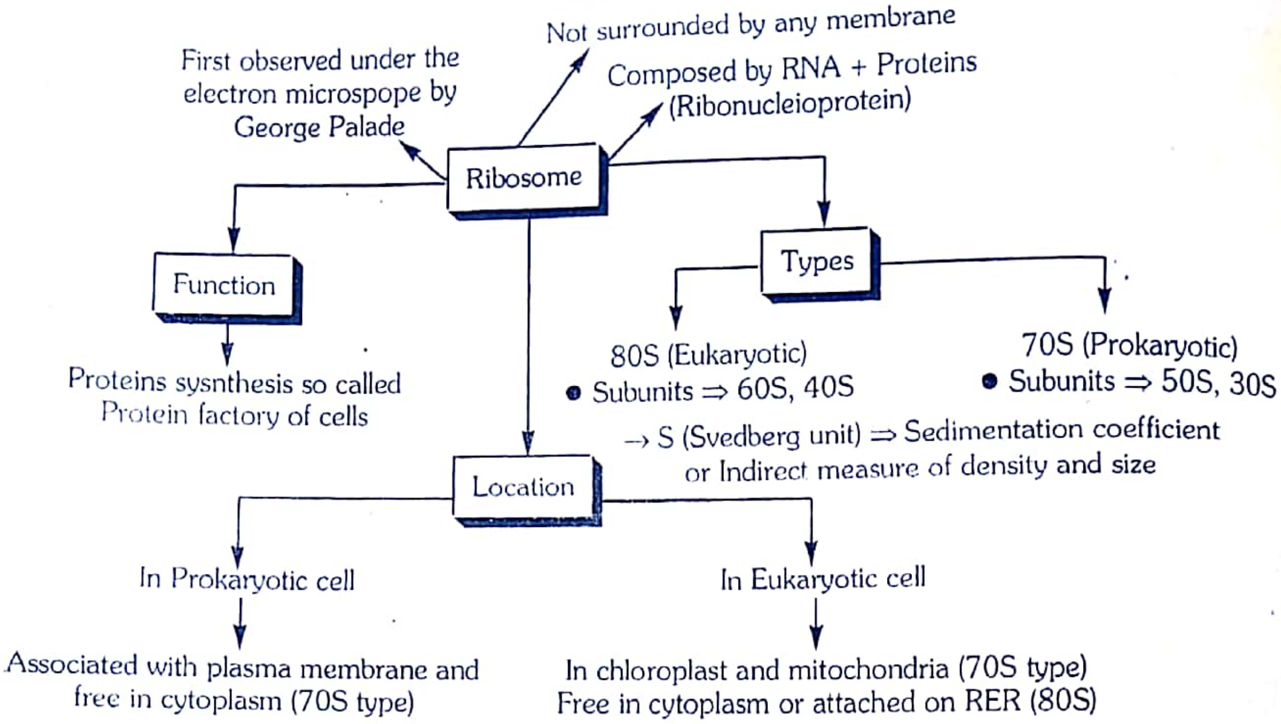
Chromoplast

- → Presence of Fat soluble Carotenoids pigments like Carotenes, Xanthophyll etc.
- → These pigments gives the parts of plant yellow, Orange or red colour

Chloroplast

- Size
  - → Length = 5–10 μm
  - → Width = 2.4 μm
- Shape
  - → Lens shaped
  - → Oval
  - → Spherical
  - → Discoid
  - → Ribbon like
- Number
  - → In **Chlamydomonas** ⇒ 1/cell
  - → In mesophyll cell ⇒ 20–40/cell
- Stroma
  - → Enzymes required for the synthesis of carbohydrates
  - → ds circular DNA molecule
  - → 70s ribosomes
- Flattened membranous sacs called thylakoids are arranged in stacks like the piles of coins called grana (singular - granum)
  - → Connection between grana ⇒ Stroma lamellae
  - → Thylakoid has lumen and it also contain pigments like chlorophyll
- Double membrane bound
  - ● Inner membrane relatively less permeable
  - ● Space limited by inner membrane ⇒ Stroma

RIBOSOMES


Ribosome
Not surrounded by any membrane
Composed by RNA + Proteins (Ribonucleioprotein)
First observed under the electron microspope by George Palade
Function
Proteins sysnthesis so called Protein factory of cells
Types
80S (Eukaryotic)
● Subunits ⇒ 60S, 40S
70S (Prokaryotic)
● Subunits ⇒ 50S, 30S
→ S (Svedberg unit) ⇒ Sedimentation coefficient or Indirect measure of density and size
Location
In Prokaryotic cell
Associated with plasma membrane and free in cytoplasm (70S type)
In Eukaryotic cell
In chloroplast and mitochondria (70S type)
Free in cytoplasm or attached on RER (80S)

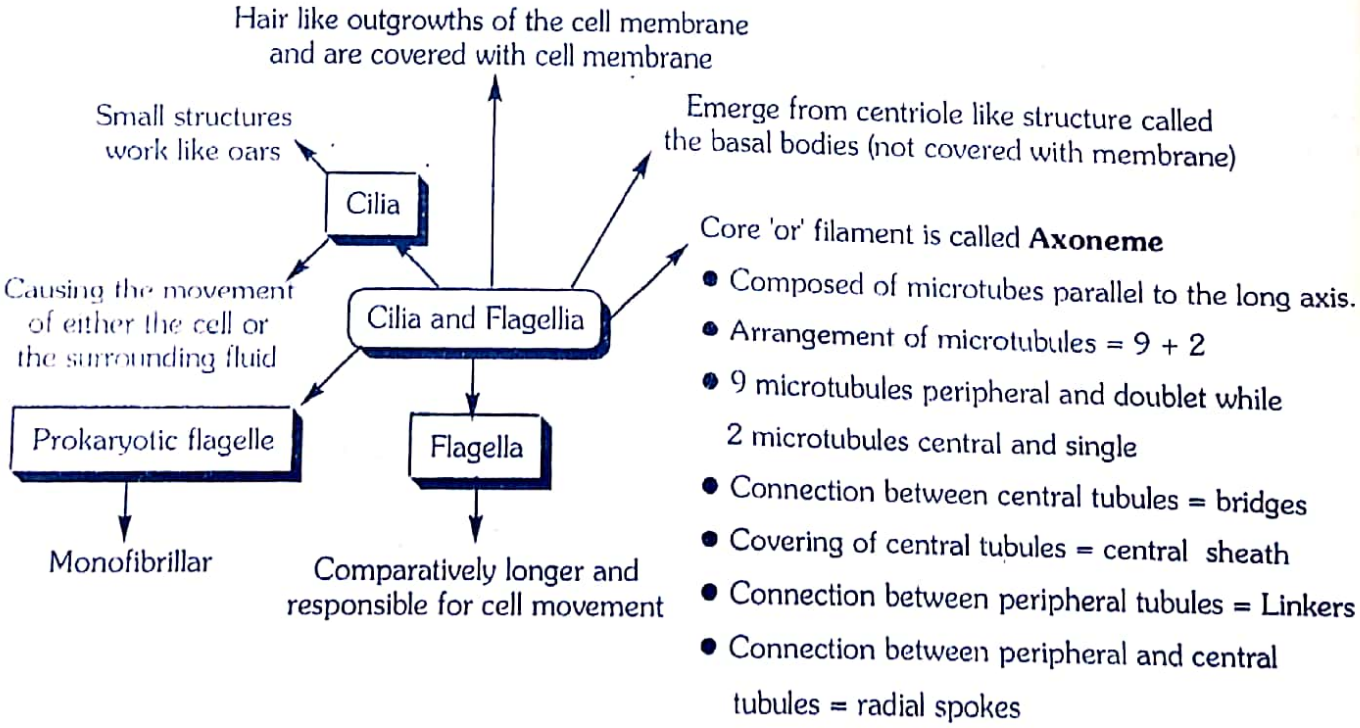
CYTOSKELETON

→ Network of filamentous proteinaceous structures.

(Microfilaments + Microtubules + ER) present in cytoplasm.

→ Functions → Mechanical support, Motility, Maintenance of the Shape of the cell.

CILIA AND FLAGELLA

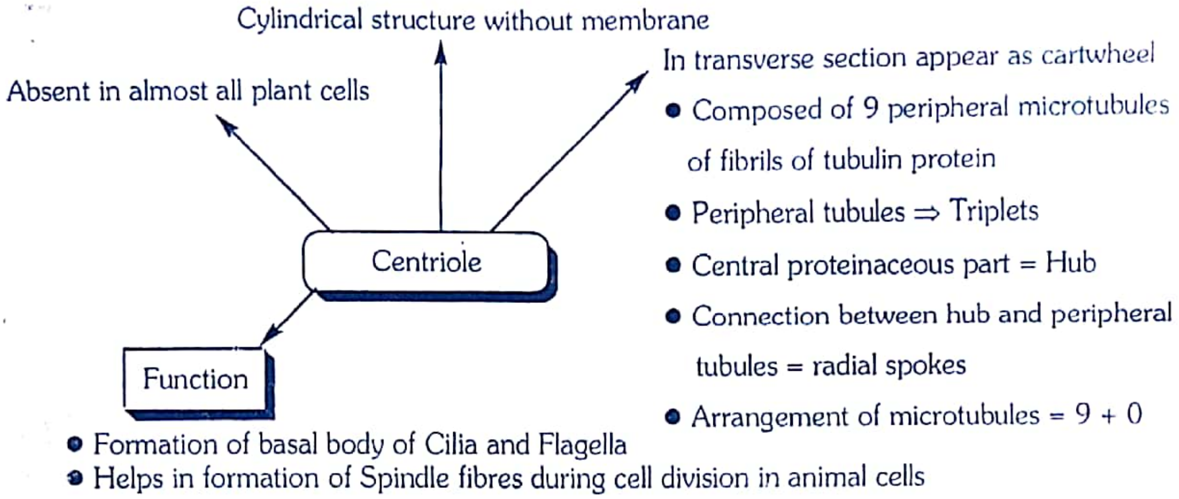

Hair like outgrowths of the cell membrane and are covered with cell membrane
Small structures work like oars
Cilia
Emerge from centriole like structure called the basal bodies (not covered with membrane)
Causing the movement of either the cell or the surrounding fluid
Cilia and Flagellia
Prokaryotic flagelle
Monofibrillar
Flagella
Comparatively longer and responsible for cell movement

Core 'or' filament is called **Axoneme**

- Composed of microtubes parallel to the long axis.
- Arrangement of microtubules = 9 + 2
- 9 microtubules peripheral and doublet while 2 microtubules central and single
- Connection between central tubules = bridges
- Covering of central tubules = central sheath
- Connection between peripheral tubules = Linkers
- Connection between peripheral and central tubules = radial spokes

CENTROSOME AND CENTRIOLES

→ Centrosome = 2 centrioles (Perpendicular to each other) + Surrounding amorphous pericentriolar material.



Centriole

Cylindrical structure without membrane

Absent in almost all plant cells

In transverse section appear as cartwheel

- Composed of 9 peripheral microtubules of fibrils of tubulin protein
- Peripheral tubules ⇒ Triplets
- Central proteinaceous part = Hub
- Connection between hub and peripheral tubules = radial spokes
- Arrangement of microtubules = 9 + 0

Function

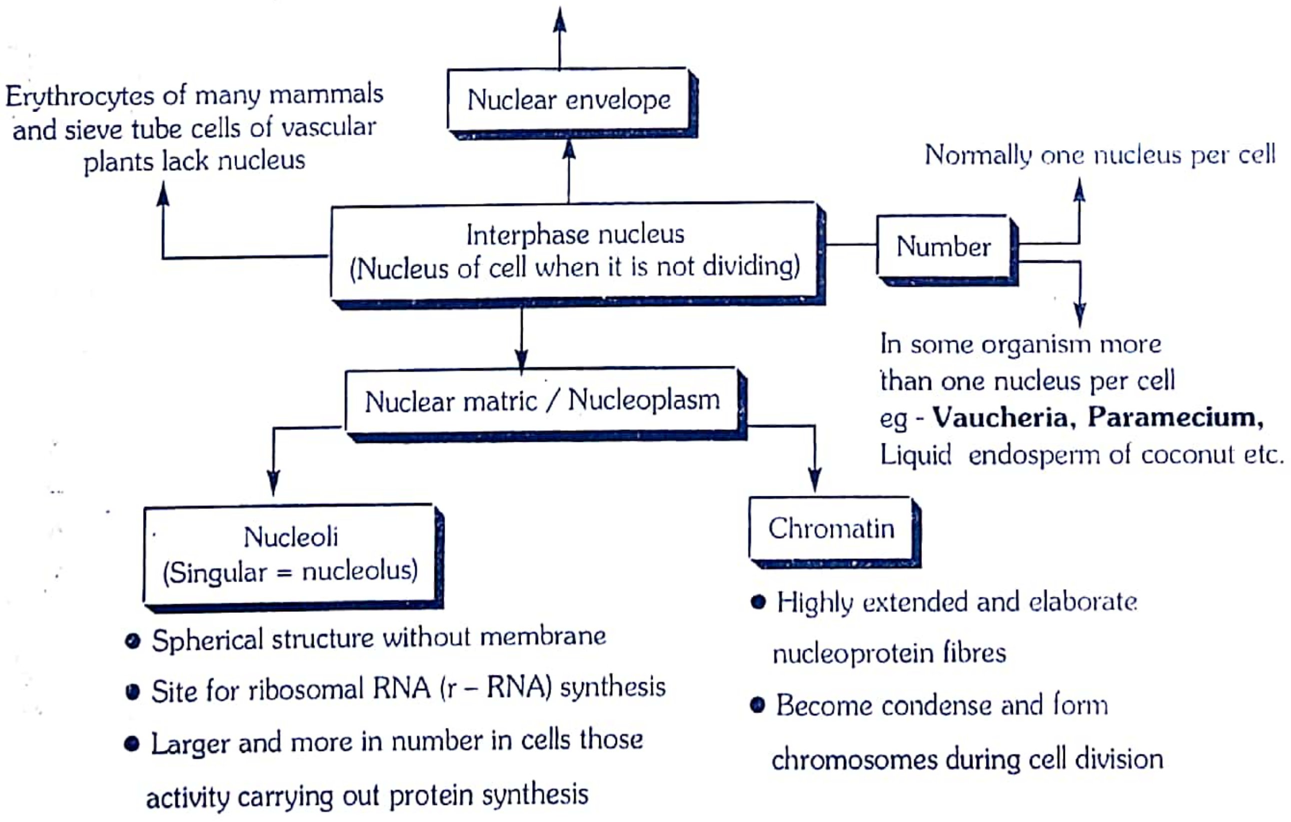
- Formation of basal body of Cilia and Flagella
- Helps in formation of Spindle fibres during cell division in animal cells

NUCLEUS

→ First described by Robert Brown.

→ Term "Chromatin" was given by Flemming.

→ Staining of chromatin = by basic dyes



Interphase nucleus (Nucleus of cell when it is not dividing)

Nuclear envelope

- Consist of two parallel membranes
- Space between both the membranes ⇒ Perinuclear space (10 – 50nm)
- Nuclear envelope is interrupted by minute pores formed by fusion of both the membranes
- Through pores movement of RNA and proteins takes place between cytoplasm and nucleus.
- Outer membrane remain continuous with ER

Erythrocytes of many mammals and sieve tube cells of vascular plants lack nucleus

Number

Normally one nucleus per cell

In some organism more than one nucleus per cell eg - **Vaucheria, Paramecium,** Liquid endosperm of coconut etc.

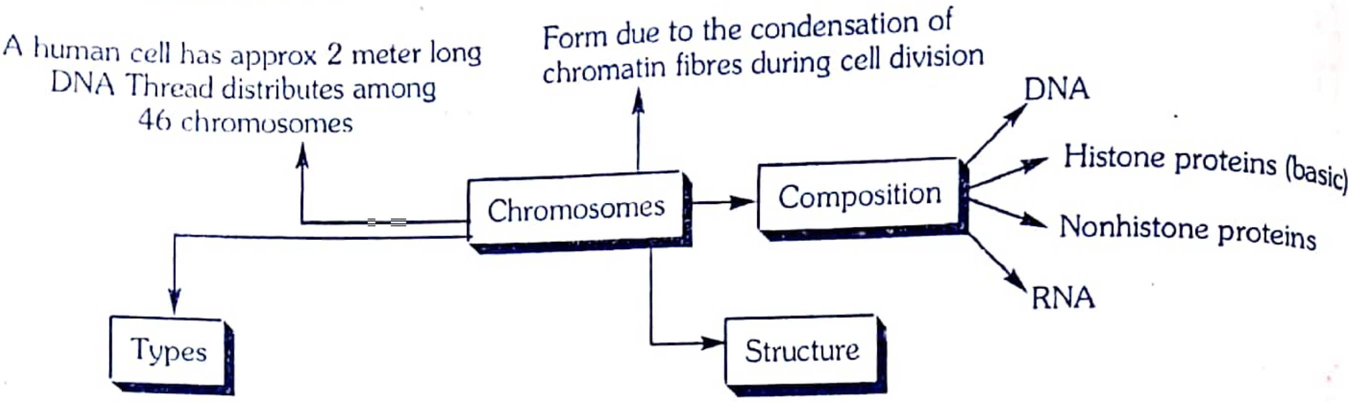
Nuclear matric / Nucleoplasm

Nucleoli (Singular = nucleolus)

- Spherical structure without membrane
- Site for ribosomal RNA (r – RNA) synthesis
- Larger and more in number in cells those activity carrying out protein synthesis

Chromatin

- Highly extended and elaborate nucleoprotein fibres
- Become condense and form chromosomes during cell division


A human cell has approx 2 meter long DNA Thread distributes among 46 chromosomes
Form due to the condensation of chromatin fibres during cell division
Chromosomes
Composition
DNA
Histone proteins (basic)
Nonhistone proteins
RNA
Types
Structure

On the basis of position of centromere

- Metacentric – centromere in middle
- Submetacentric – Centromere slight away from middle
- Acrocentric – Centromere close to the end of chromosome
- Telocentric – Centromere at terminal position

- Primary constriction or centromere
- Each centromere has to disc shaped structures called Kinetochores
- Few chromosomes have secondary constriction at constant location
- Fragment or part of chromosome after secondary constriction = Satellite

MICROBODIES

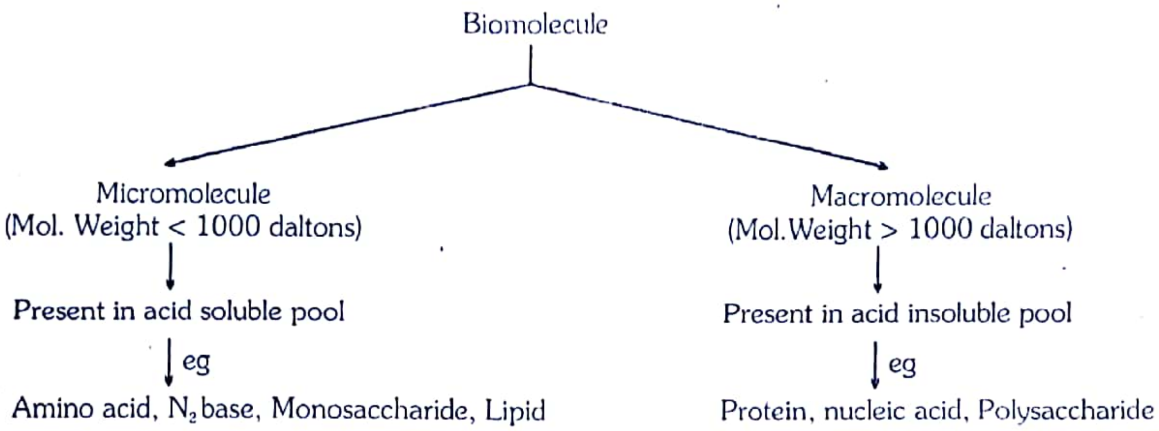
→ Membrane bound minute vesicles contain enzymes.

→ Present in both plant and animal cells.

→ Ex. Pexoxisome, Glyoxysome, Sphaerosome etc.

BIOMOLECULES (PROTOPLASM)

Biomolecule→ All the carbon compound that Present in living tissue.


Biomolecule
Micromolecule
(Mol. Weight < 1000 daltons)
Present in acid soluble pool
eg
Amino acid, N₂ base, Monosaccharide, Lipid
Macromolecule
(Mol.Weight > 1000 daltons)
Present in acid insoluble pool
eg
Protein, nucleic acid, Polysaccharide

- But exceptionally lipid is micromolecule but present in acid insoluble fraction.

CARBOHYDRATE

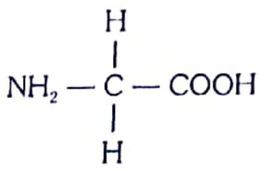
- Although polysaccharide is non reducing but in a polysaccharide chain one end is reducing and another end is non reducing.
- Starch form helical structure so starch can hold I_2 molecules in the helical portion so starch-I_2 is blue in colour While cellulose have linear structure so it cannot hold I_2 and don't give Iodine test.
- Paper made from plant pulp is cellulose.
- Difference between gums and fevicol → Gums are natural mucopolysaccharide while fevicol is synthetic rubber based adhesive.

LIPID

- Fatty acids are of two types →
  (i) Saturated→ eg palmitic acid (16 carbon compound), stearic acid
  (ii) unsaturated→ eg oleic acid, Linoleic acid, Linolenic acid, Arachidonic acid (20 carbon compound)
- Glycerole is trihydroxy propane.
- Lipids are called fats and oils on the basis of melting point. Oils have lower melting point and fats have higher melting point.
- Some lipids also have phosphorus like lecithin.

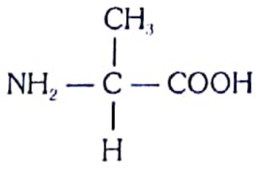
PROTEIN

- Proteins are heteropolymer of amino acids.
- Amino acids contain an amino group and carboxylic group on the same carbon i.e. the α-carbon so they are called α-amino acid.
- Amino acid are substituted methane.



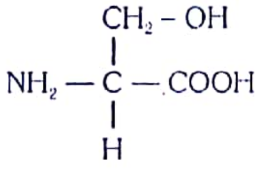
$$NH_2-\overset{H}{\underset{H}{C}}-COOH$$

Glycine



$$NH_2-\overset{CH_3}{\underset{H}{C}}-COOH$$

Alanine



$$NH_2-\overset{CH_2-OH}{\underset{H}{C}}-COOH$$

Serine

- Amino acids are of two types:-
  (i) Essential amino acid (ii) Non essential amino acid
- Protein show mainly four type of configuration:-
  (A) Primary configuration (B) Secondary configuration
  (C) Tertiary configuration (D) Quaternary configuration
- Tertiary structure is absolutely necessary for the many biological activities of protein.

DNA

- In mostly living DNA is a heridatory long material. In some viruses RNA also act as heridatory long material.
- RNA out as adaptor (tRNA), structural (rRNA) and in some condition ctalyst (Rhibozyme).
- In a DNA molecule one purine always pairs with a pyrimidine. This generates approximately uniform distance between the two strands of DNA.
- In DNA plane of one base pair stacks over the other in double helix. This, in addition to H-bonds, confers stability of the helical structure of DNA.
- Difference between DNAs and DNase is that DNAs menas many DNA and DNase means DNA digestive enzymes.
- Oswald Avery, Colin Macleod and Maclyn Mccarty firstly proved the genetic material is DNA.
- Alfred Hershey and Martha Chase Firstly proved that in bacteriophage DNA is also genetic material.
- A molecule that can act as a genetic material must fulfil the following criteria–

  (i) It should be able to generate it's replica (replication)

  (ii) It should chemically and structurally be stable

  (iii) It should has property of mutation.

  (iv) It should be able to express itself in the form of "Mendelian Characters".
- The presence of thymine at the place of uracil also provide additional stability to DNA.
- Both DNA and RNA are able to mutate. In fact, RNA being less stable, mutate at faster rate so virus having RNA genome and having shorter life span mutate and evolve faster.
- RNA was the first genetic material.

DNA-REPLICATION

- The machinery and the enzyme :-
- The main enzyme of replication is DNA-dependent DNA polymerase.
- It uses DNA template to catalyse the polymerisation of deoxyribonucleotides and also have to catalyse the reaction with high degree of accuracy.
- DNA polymerase catalyse polymeristion in one direction that is 5' – 3'.
- On one stand (3' – 5'), the replication is continuous and on the other (5' – 3') strand,it is discontinuous.
- The discontinuous fragments are later joined by DNA ligase.
- DNA polymerase can not initiate the process of replication
- Any failure in cell division after DNA replication result into polyploidy.

TRANSCRIPTION

- If both strands act as a template during transcription they would code for RNA molecule with different sequence and If they code for proteins the sequence of amino acid in these proteins would be different and another reason that if the two RNA molecule produced they would be complementary to each other and fom a ds RNA which prevent translation of RNA.
- A transcription unit of DNA has three region

  (i) A promoter

  (ii) The structural gene

  (iii) A terminator

  Cistrone in a part of DNA which form polypeptide chain.
- The DNA dependent RNA polymerase catalyse the transcription process only in 5' – 3' direction.
- Sigma factor and Rho factor are also involve in transcription for initiation and termination.
- In eucaryotes after transcription splicing process also occured.
- The split gene represent an ancient (primitive) feature of gene.
- The splicing process represent the dominance of RNA world.

GENETIC CODE

- H.G. Khorana artificially synthesized an mRNA.
- Severo ochoa enzyme (RNA polymerase enzyme) is also helpful in polymerising RNA with defined sequences in a template independent manner.
- Genetic code is triplet, nonambiguous, degenerate, commaless and nearly universal.

TRANSLATION

- Translation reffers to the process of polymerisation of amino acid to form a polypeptide chain on the basis of sequence of nucleotides on mRNA.
- Firstly amino acid are activated and attached to its tRNA called charging of tRNA.
- The ribosome also act as a catalyst (23's'rRNA, ribozyme) for the formation of peptide bond.
- A translation unit on mRNA is the sequence of RNA that is flanked by the start codon (AUG) and the stop codon and codes for a polypeptide.
- The UTR(untranslated regions) present on mRNA are required. for efficient translation process (by recognising the smaller subunit of ribosome by mRNA and by prevent the degradation of mRNA)
- **Secondary metabolites :** These are the product of metabolic reactions but they are not directly involve in the growth, reproduction and developnent of organism. Many secondary metabolites are used in human-welfare eg. drugs, rubber, spices etc.

CELL CYCLE & CELL DIVISION (MITOSIS)

Interphase
- Resting stage
- Phase between two successive M-phase
- More then 95% duration of cell cycle
- Preparation for division

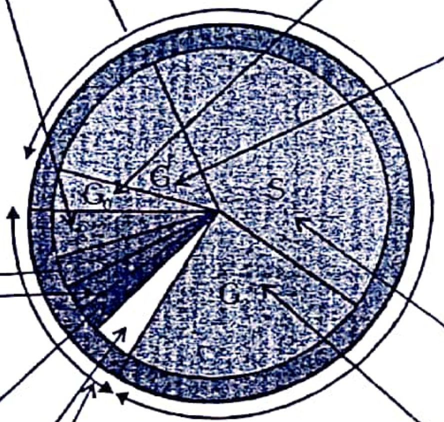
Cytokinesis
- Division of Cytoplasm
- Furrow method in animal cell
- Cell plate method in plant cell

Telophase (T)
- ER, GC, Nucleolus, Nuclear membrane reform
- Begining of the final stage of Mitosis
- Chromosomes reach their respective pole
- Chromosomes decondense and lose their individuality

Anaphase (A)
- Cetromere split
- Sister chromatid separate
- Chromosome move towards opposite pole

Metaphase (M)
- Condensation of chromosome completed.
- Morphology of chromosome studied
- Spindle fibres attach with Kinetochore
- Chromosomes lie at the equator

Prophase (P)
- Condensation of chromatin material
- Centrioles start to move towards opposite pole
- Both chromatid of chromosome are visible
- Initiation of the assembly of Microtubules
- At the end GC, ER, nucleolus and nuclear membrane disappeared



Quiescent stage
- Metabolically active but no longer proliferate
- Heart cell in permanent G_0
- Can divide depending on requirement of organism

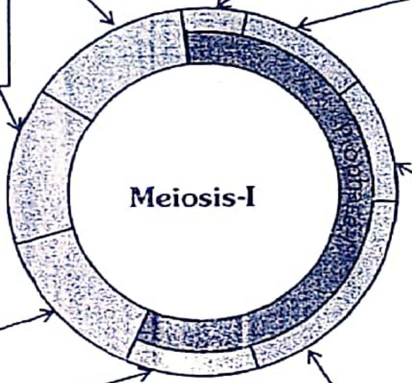
G_1 phase
- Interval between mitosis and initiation of DNA replication.
- Cell is metabolically active and continuously grows
- Most of the organelles duplicate

S phase
- Replication of DNA
- Centriole duplication (Cytoplasm of animal cell)
- Synthesis of histone protein
- Chromosome number remains same but DNA content become double

G_2 phase
- Protein formed for mitosis
- Cell growth continues

M-phase
- Actual phase when division occurs
- Most dramatic period
- Reorganisation of virtually all component of the cell
- Starts with *karyokinesis and ends with cytokinesis*

CELL CYCLE & CELL DIVISION (MEIOSIS)



Leptotene (L)
- Chromosome become visible under light microscope
- Compaction of chromosome continuous

Zygotene (Z)
- Pairing of homologous chromosomes
- Pairing is called synapsis
- Paired chromosome called bivalent
- Formation of synaptonemal complex

Pachytene (P)
- Bivalent or tetrad are clearly visible
- Appearance of recombination nodule
- Crossing over occurs between non-sister chromatids of the homologous chromosomes
- Recombinase enzyme involved in crossing over
- At the end, recombination completed, leaving the chromosome linked at the site of crossing over

Diplotene (Di)
- Dissolution of synaptonemal complex
- Homologous chromosome seperate from each other
- X-shaped structure called chaismata are visible
- Longest phase of meiosis which can lasts for month or years in some vertebrate oocyte.

Diakinesis (Dia)
- Final stage of prophase-I
- Marked by terminalisation of chaismata
- Chromosome are fully condensed
- Spindle is assembled to prepare the homologous chromosome for separation
- Nucleolus disappear and nuclear envolope also break down

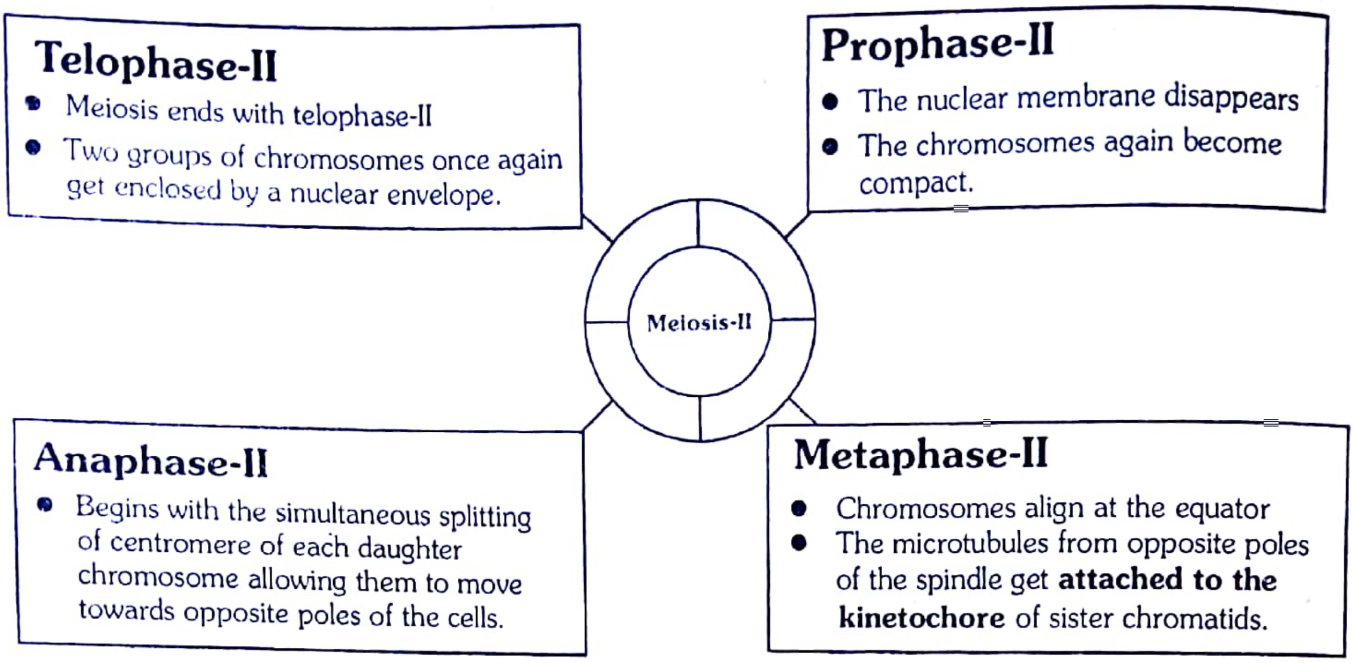
Metaphase-I
- Bivalent chromosome align on equatorial plate
- Spindle fibres attach to the pair of homologous chromosome

Anaphase-I
- Homologous chromosome separated
- Sister chromatid remains associated

Telophase-I
- Nuclear membrane and nucleolus reappear
- Chromosomes decondense but do not reach the extremely extended state

  Cytoplasmic division start

MEIOSIS-II



Prophase-II

- The nuclear membrane disappears
- The chromosomes again become compact.

Metaphase-II

- Chromosomes align at the equator
- The microtubules from opposite poles of the spindle get **attached to the kinetochore** of sister chromatids.

Anaphase-II

- Begins with the simultaneous splitting of centromere of each daughter chromosome allowing them to move towards opposite poles of the cells.

Telophase-II

- Meiosis ends with telophase-II
- Two groups of chromosomes once again get enclosed by a nuclear envelope.

Significance of mitosis :

- Mitosis or the equational division is usually restricted to the diploid cell. Where as some lower plants and some insects haploid cells mitoticaly divide.
- Mitosis results in the production of daughter cell with identical genetical complement usually.
- The growth of multicellular organism is due to mitosis.
- Cell growth results in disturbing the ratio between the nucleus and cytoplasm, which is restored by mitosis.
- The cells of the upper layer of the epidermis, cells of the lining of the gut, and blood cells are being constantly replaced by mitosis.
- Mitosis in the meristematic tissue – the apical and the lateral meristem (cambium), results in a continuous growth of plants throughout their life.

Significance of meiosis :

- **Conservation** of specific chromosome number of each species is achieved across generation in sexually reproducing organism.
- Increases the **genetic variability** in the population of organisms from the one generation to the next.
- Variations are very important for the process of evolution.

PLANT PHYSIOLOGY

TRANSPORT IN PLANTS

- Over small distances substances move by **difusion** and **cytoplasmic steaming.**
- Long distance transport is called TRANSLOCATION
- Organic substances move - Multidirectional
- Inorganic substances & H_2O → Unidirectional
- Diffusion - passive, random slow and not dependent on living system.
- Gaseous exchange-is due to diffusion
- Diffusion rate depends on concentration gradient, permeability, temperature & pressure.
- **Facilitated diffusion** → Carried out for those substances having hydrophilic moiety
  Gradient required, carrier mediated, without energy
- Water channels made up of aquaporins
- **Active transport** → Uphill transport, energy & carrier proteins both required.
- Common features to Facilitated and Active transport → saturation, selectivity, Inhibition, Hormone regulation
- Water potential → difference of Kinetic energy
- Solute potential → loss of free energy (Kinetic energy) due to addition of solutes
- Pressure potential → change in free energy due to external pressure (other than atmospheric pressure)
- Tonoplast and plasma membrane are two important determinants of movement of molecules in or out of the cell.
- Net direction and rate of osmosis depends on both **pressure gradient** and **concentration gradient.**
- $OP = -\psi_s$
- During plasmolysis water lost first from cytoplasm and then from vacuole
- Imbibition depends on diffusion, water potential gradient & affinity between adsorbant and liquid
- Bulk flow - can be acheived either through positive hydrostatic pressure gradient or negative hydrostatic pressure gradient.
- Xylem – water, minerals and organic nitrogen, hormones
- Apoplastic path – Cellwall & intercellular space (Non living path)
- Symplastic path – Systems of interconnected protoplasts (Living path)
- Root-pressure – positive hydrostatic pressure, leads to guttation, modest push in overall water transport, greatest contribution - reestablishments of continuity of water column.
- Cell wall of guard cells show radial arrangement of microfibrils.
- **Cohesion, adhesion** and **surface tension** - are three physical properties of water which provide - **Tensile strength** and **capillarity.**
- Evolutions of C_4 photosynthetic path is for maximising CO_2 utilisation and to minimising water loss.
- Plants obtain their most of the carbon & oxygen from CO_2
  Plants obtain most of their minerals from soil actively because
  (1) Minerals present in soil as charged particles
  (2) In soil mineral concentration is lower than plant cell.
- Active mineral absorption helps in creation of waters potential gradient.
- Some ions can move passively by mass flow.
- Transport proteins of endodermal cells are control points, where a plant adjust the quantity and types of solutes that reach to xylem, hence it allow transport of ions in one direction only.
- Chief sinks for mineral elements – apical & intercalary meristem, young leaves, developing flowers, fruits, seeds & storage regions.
- **Mobile elements** – Remobilise from older part to young parts e.g. → Mo, Ni, Zn Mg N, P, K
  Immobile elements – can't mobilise from old to young parts B. S, Ca, Co, Fe
- Small amount of P & S carried as organic compounds
- Small amount of minerals exchange between xylem & phloem.

- Source and sink may reversed depending on Seasons or needs of plants
- Phoem translocation – water, sucrose, other sugars, hormones and amino acids.
- Accepted mechanism for sugar translocation – Masss flow hypothesis (osmotically active and chemically inert sugar translocation – mostly in form of Sucrose)
- Phloem translocation – Active process (Both loading and unloading needs energy)
- In sink sucrose – either get changed to starch or get consumed.

Phloem translocation – is due to water potential gradient and pressure gradient and it follows symplastic path.

MINERAL NUTRITION

⇒ **Hydroponics** is the technique of growing plants in a nutrient solution. This concept, for the first time demonstrated by German Botanist Julius Von Sach.

- By hydroponics method, essential elements are identified and their deficiency symptoms can be discovered.
- Hydroponics has been successfully employed for commercial production of **tomato, seedless cucumber** and **lettuce**.

⇒ **Macronutrients – Required in excess of 10 m mole kg^{-1} of dry matter.** eg. C, H, O, N, P, S, K, Ca & Mg.

⇒ **Micronutrients – Required in amount less than 10 m mole kg^{-1} of dry matter.** eg. Fe, Cu, Zn, Mn, Mo, Cl, B & Ni.

- **C, H & O** are **non minerals** because not absorbed in the form of ions, while other nutrients are **minerals (absorbed in the form of ions from soil).**

⇒ **Beneficial elements** (Not essential) – Na, Si, Co, Se.

⇒ **Nitrogen – Absorbed in the form of NO_3^- (Nitrate),** NO_2^- (Nitrite) and NH_4^+ (Ammonium) (Mainly NO_3^-).

⇒ **Phosphorus** – Absorbed in the form of $H_2PO_4^-$ or HPO_4^{-2}.

⇒ **Potassium** – Required in **more abundant quantities in meristematic tissues.**

⇒ **Calcium – In the middle lamella** as calcium pectate and **formation of mitotic spindle.**

⇒ **Magnesium– Constituent of chlorophyll structure** and **maintain the ribosome structure.**

⇒ **Sulphur – Present in amino acids – Cysteine and methionine.** Constituent of thiamine, biotin, Coenzyme A and **Ferredoxin.**

⇒ **Iron** – Absorption in the form of Fe^{++}. **Part of ferredoxin and Cytochromes. Not the constituent of chlorophyll but essential for the formation of chlorophyll.**

⇒ **Manganese –** Involved in **splitting of water (photolysis)** in photosynthesis.

⇒ **Zinc** – Needed in the **synthesis of auxin.**

⇒ **Copper –** Like iron, involved in redox reaction ($Cu^{+} \rightleftarrows Cu^{+2}$) as a part of plastocyanin (PC), **cytochrome a and a_3.**

⇒ **Boron** – Absorbed as BO_3^{-3} or $B_4O_7^{-2}$. Required for **pollen germination** and **carbohydrate translocation.**

⇒ **Molybdenum – Absorbed in the form of MoO_2^{+2} (molybdate ion).** Participate in **nitrogen metabolism** as the part of enzymes. (Nitrogenase and Nitrate reductase.)

⇒ **Chlorine** – Involved in **water splitting** in photosynthesis (water splitting involved - Mn, Cl and Ca but main role is of Mn).

- Essential **Mineral element** required by plants in the **greatest amount – Nitrogen.**
- Among **micronutrients Iron is required in greatest amount.**
- **Actively mobile elements –** N, K, Mg (Deficiency symptoms first in senescent leaves).
- **Immobile Elements –** Ca, S (deficiency symptoms first in young tissues)
- The concentration of essential element below which plant growth is retarded is termed as **critical concentration.**
- ***Deficiency Symptoms -***

(i) **Chlorosis** (loss of chlorophyll leading to yellowing in leaves) – N, K, Mg, S, Fe, Mn, Zn, Mo.
(ii) **Necrosis** (Death of tissues particularly leaf tissues) – Ca, Mg, Cu, K.
(iii) Inhibition of cell division – N, K, S, Mo.
(iv) Delay flowering – S, Mo.

- Micronutrient concentration in tissues that reduces the dry weight of tissues by about 10 percent is considered as **toxic concentration.**
- **Manganese toxicity** (excess of Mn) induce **deficiency of Fe, Mg and Ca.** The prominent symptom of this toxicity is the appearance of brown spots surrounded by chlorotic veins.
- **Absorption of ions – Both active and passive** (mainly active)
- Two phases of absorption of ions –

  (i) **First phase** – Entry of ions **in apoplast** (Passive movement)

  (ii) **Second phase** – Entry of ions **in symplast** (both active and passive, mainly active.)

METABOLISM OF NITROGEN

- **Nitrogen Fixation –** Conversion of nitrogen (N_2) into ammonia (NH_3) or Nitrate (NO_3^-) [Nitrate compounds]
- **Electrical 'or' atmospheric nitrogen fixation –** N_2 to NO_3^- (Nitrate compounds)
- **Industrial and biological nitrogen fixation** – N_2 to NH_3
- **Nitrification –** NH_3 to NO_3^-.
- **Ammonification –** Dead biomass (organic nitrogen like protein) to NH_3.
- **Denitrification –** $NO_3^- \longrightarrow N_2$
- **Nitrifying bacteria** (*Nitrosomonas, Nitrococus, Nitrobacter*) are **chemoautotrophs**.
- **Denitrifying bacteria –** *Pseudomonas* and *Thiobacillus.*
- **Free living** nitrogen fixing **aerobic** microbes – ***Azotobacter*** and ***Beijernickia.***
- **Free living** nitrogen fixing **anaerobic** microbe – *Rhodospirillum.*
- Both ***Rhizobium*** and ***Frankia*** are free living in soil but as **symbiont** can fix atmospheric nitrogen.
- ***Rhizobium*** **– in legumes like *alfalfa*, sweet clover, sweet pea, garden pea, lentils, broad bean, clover beans etc.**
- **Frankia – Alnus** and Casuarina (Non-legume plants)
- The **root nodules** in **legume plants** are **red or pink** due to presence of **leg-haemoglobin (oxygen scavenger** which protect the nitrogenase enzyme from oxygen.)
- **Nitrogenase** enzyme is a **Mo - Fe protein.**
- In biological nitrogen fixation **8 ATP** are required for **each NH_3** production. In symbiotic nitrogen fixation this **energy** is **obtained from the respiration of the host cells.**
- **Reductive amination** – Glutamic acid / Glutamate formation.
- **Transamination –** formation of other amino acids from glutamic acid.
- **Nitrogen is transported** to other parts of the plants from root, mainly **in the form of amides** (Asparagine and glutamine) **via xylem** since **amides contain more nitrogen than the amino acids.**
- For the formation of amide from amino acid, the hydroxyl part of the acid is replaced by amino (NH_2) group. It is called **Catalytic Amidation.**
- In **Soyabean**, nitrogen is transported as **ureides**. These compounds also have high nitrogen to carbon ratio.

PHOTOSYNTHESIS

- It is an **physicochemical process.**
- **Half leaf experiment** showed that CO_2 is required for photosynthesis.
- **Joseph Priestley –** Proposed the **Concept of gaseous exchange** by plants with the help of **bell jar experiment.**
- **Jan Ingenhousz –** Showed the importance of **Sunlight** and **Green colour** in photosynthesis by using a similar setup as the one used by Priestley.
- **Julius von Sachs –** Provided evidence for **production of glucose** and its **storage as starch.**
- **T.W. Engelmann –** Proposed **action spectrum of photosynthesis** (i.e. maximum photosynthesis occurs in blue light and red right) Experiment on green filamentous **alga *Cladophora*.**
- **Cornelius Van Niel –** Suggested that O_2 evolved during photosynthesis **comes from H_2O**, not from CO_2. Experiments on purple and green sulphur bacteria.

- There is a clear **division of labour** (distribution of work) within the **chloroplast** i.e. **membrane system** (grana thylakoids and stroma lamellae) is responsible for **light reaction** and **stroma** is the place for **dark reaction.**
- In the **chromatogram**, **chlorophyll 'a'** shows **bright or blue green colour, chloropyll 'b'** shows **yellow green colour, xanthophyll - yellow & carotenes - yellow - orange.**
- **Accessory pigments** (chlorophylls other than reaction centre, xanthophylls and carotenoids) absorb light and transfer the energy to chlorophyll a (reaction centre) thus accessory pigments enhance the efficiency and range of absorption for photosynthesis.

  These pigments also **protect chlorophyll a from photo-oxiation.**
- One molecule of chlorophyll **a (reaction centre) + Antennae molecules (LHC** = Light Harvesting Complex) **= Photosystem.**
- **PS-I** – Reaction centre (Chl 'a' 700 or $\mathbf{P_{700}}$)
- **PS-II** – Reaction centre (Chl 'a' 680 or $\mathbf{P_{680}}$)

  P = Peak of absorption
- Noncyclic photophosphorylation is called the **Z scheme** (due to characteristic shape on a redox potential scale).
- **Water splitting (Photolysis of water)** occurs on the inner side **(lumen side) of the thylakoid membrane.**
- Products of **noncyclic photophosphorylation** – ATP, NADPH + H^+ and O_2.
- Product of **cyclic photophosphorylation** – ATP.
- Products of light reaction which are utilised in dark reaction – ATP & NADPH + H^+.
- In grana thylakoid – both noncyclic & cyclic process occurs.
- In **stroma thylakoid** – only cyclic process occurs because stroma thylakoid / lamellae **lack PS-II** as well as **NADP reductase** enzyme.
- Primary electron acceptor from PS-I : – **Fe-S protein** (FRS)
- Primary electron acceptor from PS-II : – **Pheophytin.**
- The **chemiosmotic hypothesis** has been put forward by Peter Mitchell to **explain the mechanism of ATP synthesis** in chloroplast **(Photophosphorylation)** and Mitochondria **(oxidative phosphorylation).**
- According to this hypothesis, ATP synthesis is linked to development of a **proton gradient** across a membrane (Thylakoid membrane in chloroplast and Inner membrane in mitochondria).
- Creation of **proton gradient** in chloroplast – **Low p^H in thylakoid lumen** (More H^+).
- **Chemiosmosis requires** – a membrane, a proton pump, a proton gradient and ATPase (Two parts – F_0 / transmembrane channel and F_1).
- Melvin Calvin used **^{14}C radioisotope** to workout the complete pathway of Hexose (glucose or fructose) formation from CO_2 i.e. Calvin Cycle.
- In C_3 pathway first product of biosynthetic phase or dark reaction – **PGA** (3C)
- In C_4 pathway first product of biosynthetic phase or dard reaction – **OAA** (4C)
- In C_3 plants primary acceptor of CO_2 = Ribulose bisphosphate **(RuBP)** – 5 Carbon Ketose sugar
- In C_4 and CAM primary acceptor of CO_2 = Phosphoenolpyruvate **(PEP)** – 3 Carbons.
- **Calvin Cycle** occurs **in all photosynthetic plants** (C_3, C_4 and CAM plants)
- **Calvin Cycle** can be described under three stages – ***Carboxylation, reduction and regeneration.***
- **Carboxylation** is the **most crucial step** of the Calvin Cycle.
- Reduction step involve utilisation of 2 ATP and 2 NADPH + H^+ for 1 CO_2 molecule. Regeneration Step require 1 ATP Hence for **each CO_2, 2NADPH$_2$ and 3 ATP** are required in Calvin Cycle.
- To make **one molecule of hexose** (glucose or fructose), **6 turns of the Calvin cycle** are required. (18 ATP and 12 NADPH$_2$)
- C_4 plants are adapted to **dry tropical regions**. These plants have **Kranz anatomy** in their leaves.
- **Bundle sheath cells** or Kranz cells are characterised by having a **large number of chloroplasts, thick walls impervious to gaseous exchange** and **no intercellular spaces.**
- In **C_4 plants, PEPcase** is found **in mesophyll cells** and **RubisCO** in bundle sheath cells.
- In C_4 plants, CO_2 transported in the form of **malic acid (4C)** or **aspartic acid (4C)** from measophyll cell to bundle sheath cell.

- **RubisCO** can bind to both CO_2 and O_2. In C_3 **plants** some O_2 does bind to RubisCO (**Photorespiration**) In photorespiration 1, RuBP (5C) ⟶ 1 PGA (3C) (Phosphoglycerate) + 1, **Phosphoglycolate (2C).**
- **Photorespiration** is **wasteful process**. (Neither synthesis of sugar nor of ATP and $NADPH_2$)
- In C_4 **plants, photorespiration does not occur** because they **increase the concentration of CO_2 in bundle sheath cells** (site of RuBisCO enzyme) by **pumping** it in the form of C_4 acid. (malic acid or aspartic acid).
- **Law of limiting factor** – proposed by **Blackman**.
- **CO_2 is the major limiting factor for photosynthesis.**
- **CO_2 saturation** for **C_4 plants** – at about **360 $\mu\ell L^{-1}$/PPM** concentration of CO_2.
- **CO_2 saturation** for **C_3 plants** – at **beyond 450 $\mu\ell L^{-1}$/PPM** concentration of CO_2.
- **Current** availability of **CO_2** levels is **limiting to the C_3 plants not for C_4 plants.**
- C_3 plants respond to higher CO_2 concentration by showing increase rate of photosynthesis (experiments on **green house crops** such as **tomatoes** and **bell pepper**.), it is called **CO_2 fertilising effect.**
- For **plants in shade** or in **dense forest, light** may be the **limiting factor**.
- The dark reactions being enzymatic, are temperature controlled, **light reactions** are **less temperature sensitive**.

RESPIRATION IN PLANTS

- In cellular respiration, **carbohydrates** are **primary respiratory substrates**. Others are Fats, organic acids and proteins. **Organic acids are used in CAM plants.**
- **Cellular respiration** is an **multistep process** so that energy released in some steps can be used for ATP synthesis. If it occurs in single step, all the energy may released as heat.
- **ATP – energy currency of the cell.**
- Reasons behind absence of specialised respiratory organs in plants –
  (i) Very little transport of gases required as each plant part takes care of its own gas exchange needs.
  (ii) Plants have slow respiration rate.
  (iii) In plants, most of the living cells located quite close to the surface of the plants.
- **Glycolysis –** Greek words Glycos = Sugar, Lysis = Splitting.
  (i) Also called **EMP pathway** (E = Embden, M = Meyerhof, P = Parnas)
  (ii) **Common** in both aerobic and anaerobic respiration.
  (iii) Occurs **in cytoplasm** and it is the **partial oxidation** of hexose (glucose or fructose) into two molecules of pyruvic acid.
  (iv) **No use of O_2** and **no release of CO_2.**
  (v) Net or total ATP gain – 6 ATP or 8 ATP (2 $NADH_2$ = 4 or 6 ATP + 2 ATP by SLP = Substrate level phosphorylation)
  (vi) Direct gain of ATP = 2 ATP (by SLP) [Not count the ATP from $NADH_2$]
  (vii) In glycolysis during anaerobic respiration, net or total or direct gain of ATP = 2 ATP [as $NADH_2$ not enter into the ETS]
- Conversion of pyruvic acid to Acetyl CoA **(Link reaction)** is an **oxidative decarboxylation catalysed** by pyruvic dehydrogenase. **(Occurs in the matrix of the mitochondria)**
- ***Krebs Cycle –***
  (i) Also called **TCA** (Tri Carboxylic Acid) Cycle or **CA** (Citric Acid) Cycle.
  (ii) Occurs in the **matrix of the mitochondria.**
  (iii) Involve **4 dehydrogenations** (3 $NADH_2$ and 1 $FADH_2$) and **2 decarboxylations** (2 CO_2).
  (iv) **Net or total ATP gain – 12 ATP** (3 $NADH_2$ = 9 ATP + 1 $FADH_2$ = 2 ATP + 1 GTP = 1 ATP).
  [If Question is asked for 1 glucose or fructose – in above point no. - (iii) and (iv) calculation will be double as Krebs cycle occurs two times during complete oxidation of 1 molecule of glucose or fructose.]
  (v) Cycle has single 5 carbon compound – ∝-ketoglutaric acid.

- **Electron transport system (ETS) and oxidative phosphorylation –**
  (i) ETS is present **in the inner mitochondrial membrane.**
  (ii) **Five complexes –** NADH dehydrogenase (I), $FADH_2$ (II), Cytochrome bc_1 (III), Cytochrome a, a_3 & 2 Cu centres (IV) and ATP synthase (V).
  (iii) In respiration the **energy of oxidation – reduction utilised in production of proton gradient to synthesise ATP (Oxidative phosphorylation).**
  (iv) Molecular **Oxygen (O_2)** act as the **final / ultimate hydrogen (electron) acceptor** and it get reduced to water
  (v) **Mobile electron carrier – Cytochrome C** and ubiquinone (UQ) / CoQ.
- In aerobic respiration, net or total gain of ATP from one glucose or fructose – 36 ATP or 38 ATP.
- In aerobic respiration in prokaryotes – 38 ATP.
- **Respiration** is an **amphibolic pathway** (involved in both anabolism and catabolism).
- **Fermentation :-**
  (i) **Incomplete oxidation** of respiratory substrate.
  (ii) Usually anaerobic, may be aerobic.
  (iii) **Alcoholic fermentation –** in yeast, Enzymes - pyruvic acid decarboxylase and Alcohol dehydrogenase.
  (iv) **Lactic acid fermentation –** In some bacteria and in muscles, Enzyme – Lactate dehydrogenase.
  (v) Net or Total or direct gain of ATP = **2ATP.**
  (vi) **Naturally fermented beverages** (alcoholic drinks) have about **13 percent alcohol** concentration as yeast poison themselves at this concentration.
- **Respiratory Quotient (R.Q.) –**
  (i) $$\text{R.Q.} = \frac{CO_2 \text{ evolved}}{O_2 \text{ consumed}}$$
  (ii) **Depends upon the type of respiratory substrate.**
  (iii) Carbohydrates (complete oxidation) = 1, Fat = 0.7, Protein = 0.9.

ENZYME

- All enzymes are proteins (More correct – almost all enzymes are protein as some nucleic acids also behave like enzymes and called **ribozymes**).
- **Enzymes** have primary, secondary and tertiary structure like proteins (**mainly tertiary structure**).
- Inorganic catalysts work efficiently at high temperatures while **enzymes (biocatalysets) get damaged at high temperatures.**
- **Enzymes** increase the rate of any biochemical process by **lower down the activation energy** (energy difference between substrate and transition state).
- Enzymes generally function in a **narrow range** of temperature and **pH.**
- Michaelis and Menten constant (**K_m**) = Concentration of substrate at which enzymatic reaction attain $\frac{V\max}{2}$
- **Competitive inhibitors** are used in the **control of bacterial pathogens**. (Sulpha drugs are competitiv inhibitors of para-amino benzoic acid (PABA) which is required by bacteria to produce folic acid for their growth)
- According to modem classification **enzymes** are classified into **6 classes** and **each class has 4-13 subclasses**
- According to this classification each enzyme has specific **four digit number** which indicate the position of enzym in classification e.g. - Hexokinase has 2.7.1.1 number.
- **6 Classes are – Oxidoreductases, Transferases, Hydrolases, Lyases, Isomerases, Ligases.**
- **Cofactors** are non protein constituents those bound to the enzyme to make the enzyme catalytically activ
- Cofactors are of 3 types –
  (i) **Prosthetic group – tightly bound organic compound** e.g - haem group.
  (ii) **Coenzyme – Loosely bound organic compound (usually vitamins).** e.g. - NAD and NAD (Vitamin niacin).
  (iii) **Metal ions – loosely bound and inorganic**, form **coordination bonds.** e.g. - Zn for enzym carboxypeptidase.

PLANT GROWTH AND DEVELOPMENT

- Development is the sum of two processes – Growth and differentiation
- Growth is irreversible permanent increase in size of an organ or it's parts or even of an individual cell.
- Growth is accompanied by metabolic processes – both catabolic and anabolic, that occur at the expense of energy.
- Plants show open form of growth – new cells are always being added to the plant body
- Apical meristem – contribute primary growths
- Lateral meristem (vascular cambium and cork cambium) contribute lateral growth and causes increase in girth
- Growth at cellular level is principally a consequence of increase in the amount of protoplasm.
- Growth is measured by a variety of parameters like – increase in fresh weight, dry weight, lengths, areas, volume and cell number
- Period of growth is generally divided into three phases –
  Meristematic
  Elongation
  Maturation
- Cells in meristematic phase are rich in protoplasm, possess large conspicuous nuclei.
  Their cell walls are primary in nature, thin, elastic and with numerous plasmodesmeta.
- Phase of elongation charaterised by increased vacuolation, cell enlargement and new cell wall deposition
- Cell of maturation phase attain theirs maximal size in terms of wall thickening & protoplasmic modification.
- The increased growth per unit time is termed as growth rate.
- The growth rate shows an increase that may be arithmetic or geometrical.
- In Arithmetic growth only one daughter cell continuous to divide while other differentiate and matures.
- Root elongation at constant rate is the expression of arithmetic growth
- It proved linear growth curve and can be expressed as $\boxed{L_t = L_o + rt}$
- In Geometrical growth - both daughter cells continuously divide. It attain sigmoid curve if space and food is limited
- Trees with seasonal activities show sigmoids curve.
- Exponential growth (log phase of sigmoid curve) can be expressed as –

$$\boxed{W_1 = W_0 e^{rt}}$$

Here r is referred as efficiency index

- Quantitative comparisons between the growth of living system cans also be made in two ways –
  (1) **Absolute growth rate** → measurement and comparision of total growth per units time

  (2) **Relative growths rate** → growth per unit time with respect to initial parameter. $\boxed{\frac{\text{increase}}{\text{initial parameter}} \times 100}$
- Water, oxygen and nutrients are essential for growth
- Plant growth and furthers development is intimately linked to the water status of plant
- Water helps in – Turgidity, enzyme activation
  oxygen → helps in releasing metabolic energy
- Nutrients → helps in synthesis of protoplasm and act as source of energy.
- Optimum temperature range and environmental signals such as light and gravity also affect growth.

Undifferentiated cells (Shoot & root apical meristem)

↓

Differentiated cells (division ability loss) (Parenchyma, collenchyma Scleranechyma, Primary xylem & Phloem)

↓

Dedifferentiated cells (division ability regain) (Interfascicular Cambium Cork Cambium)

↓

Redifferentiated cells (division ability permanently lost) (Secondary xylem & phloem cork, secondary cortex)

- Plant growth is open – can be determinate (Plant organs) or Indeterminate (Shoot & root apices).
- Plant differentiation is also open – Same meristem have differents structures at maturity
- Final structure at maturity of cell/tissue is also determined by location of cell within.
- Development includes all changes from seed germination to senescence.
- Plant follow different pathway in response to environment or phases of life to form different kinds of structure, this ability called Plasticity
- Heterophylly in Butter cup, cotton, coriander and larkspur is an examples of plasticity
- Development in plants is under control of extrinsic (light, Temperature, water, oxygens & nutrition) and Intrinsic (Intracellular – genetic/intercellular – PGR) factors
- Plant growth regulators are small, simple molecules of diverse chemical composition

  * Auxins – indole compounds

  * Cytokinins – adenine derivatives

  * Gibberellins – terpenes

  * Abscisic acid – Carotenoids

  * Ethylene – gases
- **Growth proming activities of PGR** – Cell division, cell enlargement, pattern formation, tropic growth, flowering, fruiting & seed formation
- Plant growth promoters → Auxin, Gibberellin, cytokinin,
- Growth inhibiting activities of PGR – dormancy, Abscission, response to wound & stress.

  Plant-growth inhibitor – Abscisic and
- **Ethylene - is both promoter & inhibitor** but it is largly an inhibitor
- **Auxin - was isolated by F.W. Went from coleoptile of oat seedling**
- **Bakane (foolish seedling)** disease caused by ***Gibberella fujikuroi***
- E.Kurosawa – indentified & discovered. gibberellic acid.
- **Skoog** & **Miller** – identification & crystallisation of cytokinin
- Natural source of cytokinin → extract of vascular tissues. Yeast extracted, coconut milk or DNA
- Abscisic acid → inhibitor – B, Abscission–II and dormin.
- Cousins → reported volatile subtances froms ripened oranges.
- **First isolation of Auxin – from human urine**
- Synthesis – at growing apices of stem mainly & slight on root apicess

- Natural Auxin – IAA, IBA

  Synthetic auxin – NAA, 2, 4-D
- **Auxin functions** → Root initiation on stem cuttings
  - → Promotion of flowering in pineapple
  - → Prevents early stage fruits & leaf fall but promote abscission of older mature leaves & fruits.
  - → Promotion of Apical dominance that is why decapitation usually results in to profused branching which is used in tea plantation & hedge making.
- Induce parthenocarpy – in tomatoes
- Used as herbicides e.g. 2, 4-D destroy Dicot weed
- Xylem differentiation & cell division promotion.

Gibberellins

* More than 100 gibberellins reported from different organisms.
* GA_3 is first gibberellins to be discovered and most extensively studied.
* Elongate and improve shape of fruits like apple
* Delay in Senescence, thus fruit-can be left on the tree longer so as to extend the market period.
* Increase yield of sugarcane as much as 20 tonnes per acre.
* Speed up malting process for brewing industries.
* Early maturing in conifer so leading to early seed production.
* Promote bolting (internodal elongation) in beet, cabbages and other rosette plants.

Cytokinins

Kinetin (Synthetic cytokinin) modified form of adenine obtain from **autoclaved herring sperm DNA**

Zeatin (Natural cytokinin) isolation from **corn-Kernels** and **coconut milk.**

- Natural cytokinin synthesised in regions where rapid cell division occurs-like Root apices, developing shoot buds, young fruits etc.
- Promote - new leaves, Chloroplast in leaves, lateral shoot growth, Adventitions shoot formation
- Overcome apical dominance
- Promote nutrient mobilisation so helps in delay in leaf senescence.

ETHYLENE• Gaseous PGR (Plant Growth Regulator)

- Synthesised largely by tissues under going senescence and ripening fruits.
- Ethylene leads to * horizontal growth of dicot seedling
  * Swelling of axis
  * apical hook formation.
- Promotion of senescene and abscission of plant organs especially leaves and flowers
- Highly effective in fruit ripening
- Enhance rate of respiration during fruit repering (climatic respiration)
- Break seed & Bud dormancy
- initiates germination of peanut seeds & sprouting of Potato tubers.
- Rapid internode/petiole elongation in deep water rice.
- Root growth (especially adventitious) & Root hair formation.
- Initiation of flowring and synchronisation of fruit setting in pineapples.
- Induce flowering in Mango
- Most widely used PGR in agriculture because it regulate so many physiological processes.
- Most widely used form of Ethylene is – **ETHEPHON**

- It hasten (acceleration) fruit ripening in tomatoes and apples
- Accelerate abscission in flower & fruits (thinning of cotton, cherry & walnut).
- Promote female flower formation in cucumber to increases their yield.

ABSCISIC ACID

* General plant growth inhibitor and inhibitor of plant metabolism.

* Inhibit seed germination

* Stimulate closure of stomata

* Increase stress tolerance so called Stress hormone

- Induce seed dormancy
- ABA helps seeds to withstand desiccation and other unfavourable growth factors.
- ABA act as an antagonist of GA

- Role of PGR could be complimentary or antagonistic
- Role of PGR could be individualistic or synergistic
- Events where more than one PGR interact to affect the event →

* Dormancy in seeds/Buds

* Abscission

* Senescence

* Apical dominance

- PGR play inter cellular intrinsic control
- Several External factors like temperature and light, control growth and development via PGR.

PHOTOPERIODISM : –

Influence of relative duration of light & dark on flowering.

LDP – needs light exposure more than critical light period.

SDP – needs light exposure less than critical light period.

DNP – No correlation between exposure of light durations & induction of flower.

- Duration of light & dark are equally important
- Site of perception of light & dark duration are leaves.
- Hypothetically – any hormonal substance move from leaves to shoot apex to induce flowering.

VERNALISATION : –

Qualitative or quantitative dependance of flowering on low temperature exposure

* It prevent precocious reproductive development late in growing season.

* It enables the plant to have sufficient time to reach maturity

* Vernalisation applicable on winter varieties of wheat, rye & barley as well as biennials such as sugarbeet, cabbages & carrots

DIGESTION AND ABSORPTION

- Biomacromalecules in food cannot be utilised by our body in their original form. They have been broken dow and conveted into simple substances in the digestive system. This proces of conversion of complex food subtanc to simple absorbable forms is called digestion.

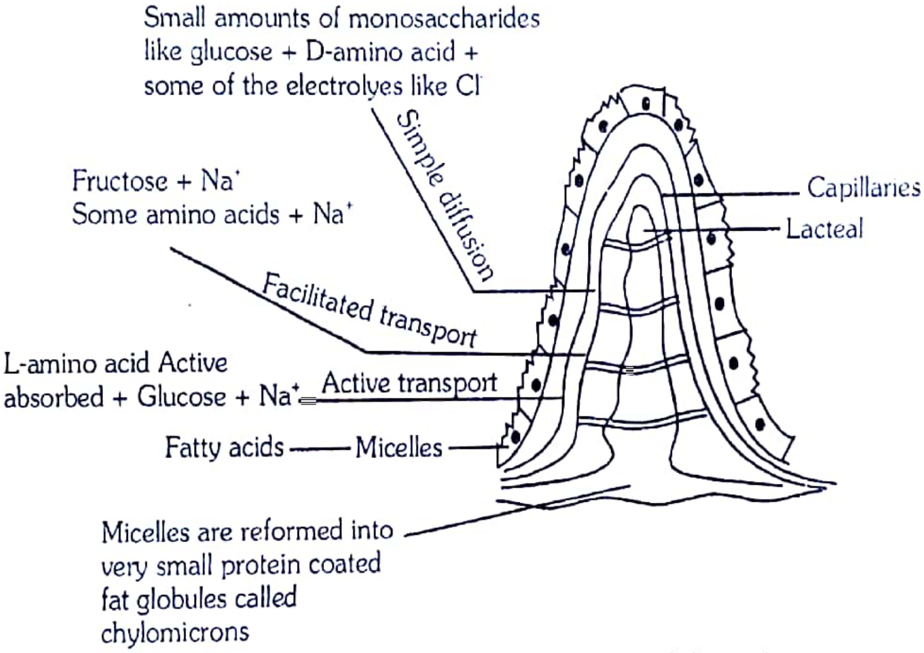
$$\text{Dipeptides} \xrightarrow{\text{Dipeptideses}} \text{Amino acid}$$

$$\text{Di and monoglycerides} \xrightarrow{\text{lipases}} \text{Fatty acids + Glycerol}$$

- No significant digestive activity occurs in the large intestine.
  The functions of large intesitine are
  (a) absorption of some water, minerals and certain drugs.
  (b) secretion of mucous, which helps on adhering the waste particles together and lubricating it for an easy passage.
- The undigested, unabsorbed substances called faeces enters into the caecum of large intestine through ileo-caecal value, which prevents the backflow of the faecal matter. It is temporarily store in the rectum till defaecation.

Absorption of digested product :

Absorption is the process by which the end products of digestion pass through the intestinal mucosa into the blood or lymph.


Small amounts of monosaccharides like glucose + D-amino acid + some of the electrolyes like Cl⁻
Simple diffusion
Fructose + Na⁺
Some amino acids + Na⁺
Facilitated transport
Capillaries
Lacteal
L-amino acid Active absorbed + Glucose + Na⁺
Active transport
Fatty acids
Micelles
Micelles are reformed into very small protein coated fat globules called chylomicrons

The summary of Absorption in different parts of digestive system

Mouth	Stomach	Small Intestine	Large Intestine
Certain drugs coming in contact with the mucosa of mouth and lower side of the tongue are absorbed into the blood capillaries lining the mouth.	Absorption of water, simple sugars and alcohol etc. takes place.	Principal organ for absorption. The digestion is completed here and the final products of digestion such as glucose, fructose, fatty acids, glycerol and amino acids are absorbed through the mucosa into the blood stream and lymph.	Absorption of water, some minerals and drugs takes place.

Disorders of digestive system :

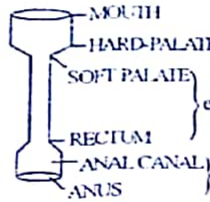
1. **Jaundice :** The liver is affected, skin and eyes turn yellow due to the deposite of bile pigments.
2. **Vomitting :** It is the ejection of stomach contents through the mouth. This reflex action is controlled by the vomit centre in the medulla. A feeling of nausea precedes vomitting.
3. **Diarrhoea :** The abnormal frequency of bowel movement and increased liquidity of the faecal discharge is known as diarrhoea. It reduces the absorption of food.
4. **Constipation :** In constipation, the faeces are retained within the rectum as the bowel movements occur irregularly.
5. **Indigestion :** In this condition, the food is not properly digested leading to a feeling of fullness. The causes of indigestion are inadequate enzyme secretion, anxiety, food poisoning, over eating and spicy food.

MOUTH is a transverse slit like aperture guarded by lips in front.

Upper lip
Lower lip

- Outer part with sebaceous glands
- Inner part with serous glands
- Lips are movable as orbicularis oris muscles are present
- Lips are immovable in WHALE and DUCK BILLED PLATYPUS

ORIGIN OF ALIMENTARY CANAL


MOUTH
HARD-PALATE
SOFT PALATE
RECTUM
ANAL CANAL
ANUS

MOUTH, HARD-PALATE } ectodermal

SOFT PALATE ... RECTUM } endodermal

ANAL CANAL, ANUS } ectodermal

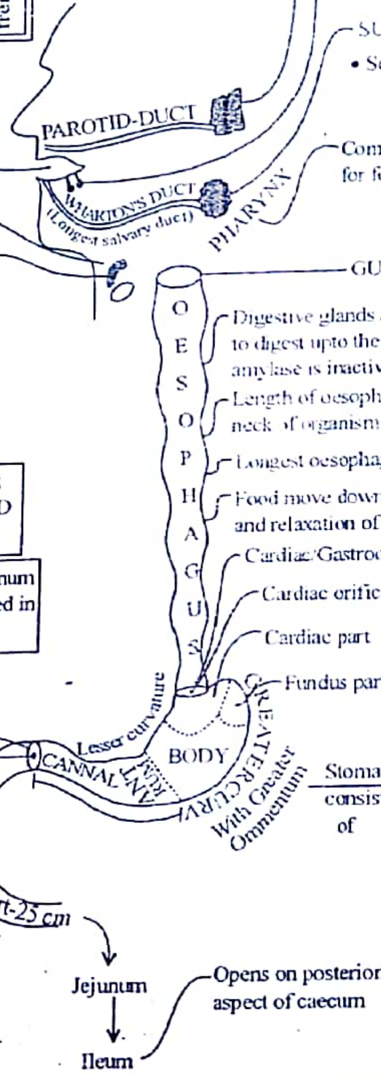
Heterodont (Different types of teeth are incisors, canines, premolars, molars (with dental formula 2123/2123)

Diphyodont (Teeth appear twice in life time)

Thecodont (Teeth in sockets)

Consist of hardest substance of animal enamel (contain maximum amount of inorganic substances)

also contain highly muscular tongue; attached to floor of oral cavity by frenulum. Contain papilla.


PAROTID-DUCT
WHARTON'S DUCT
(Longest salivary duct)
PHARYNX
Teeth in oral cavity
O E S O P H A G U S
BODY
GREATER CURVATURE
With Greater Omentum
Lesser curvature
CANNAL ANTRUM
Smallest Part-25 cm
DUODENUM
Jejunum
Ileum

EPIGLOTTIS (Cartilagenous flap prevent entry of food into Glottis)

Opening of windpipe (Glottis)

Common passage for food and air

GULLET — Dorsal opening which continues into oesophagus

- Digestive glands are absent but starch continue to digest upto the last end of oesophagus. Salivary amylase is inactivated by HCl in stomach
- Length of oesophagus depend on length of neck of organism
- Longest oesophagus is in Giraffe
- Food move downward due to regular contraction and relaxation of oesophagus called peristalsis
- Cardiac/Gastrooesophagial sphincter
- Cardiac orifice
- Cardiac part
- Fundus part

Pyloric sphincter

Pyloric Orifice

Opens on posteriomedial aspect of caecum

PAROTID GLAND

- Largest salivary glands
- Viral infection called mumps
- Present near ear
- Secret ptyalin (Salivary amylase)

SUBLINGUAL GLANDS

- Smallest salivary glands below tongue

SUBMANDIBULAR GLANDS

- Secret maximum saliva

SALIVARY GLAND

Secrete Saliva which contain 99.5% water and 0.5% electrolytes + other substances

- Lysozyme } Bactericidal in nature
- Thiocyanate }
- Glycoprotein mucin lubricate food particles
- Salivary amylase

STARCH (30%) → Maltose dextrin

SALIVA + FOOD = BOLUS

- Ptyalin is not present in saliva of rabbit because its food mainly contain cellulose
- Ptyalin is not present in carnivores as their food mainly contain protein

GASTRIC JUICE

Consists of 99.5% water + 0.2% to 0.3% HCl + rest other (enzymes, hormones, mucus)

Three phases of release of Gastric juice are :-

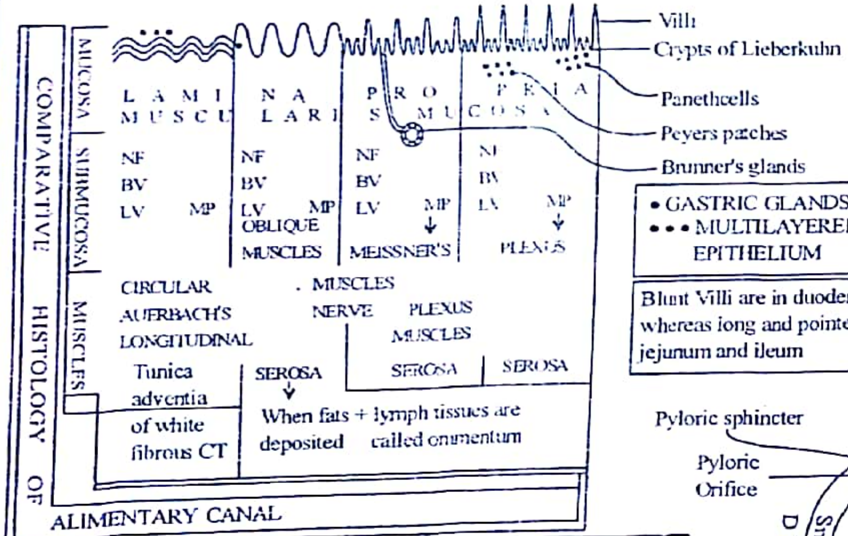
1. Cephalic phase - Parasympathetic nerves ↑ secretion of Gastric juice and sympathetic nerves ↓ secretion of gastric juice. Secretion of gastric juice is mediated by VII, IX, X Cranial nerves
2. Gastric phase
3. Intestinal phase

Stomach consist of → Gastric Glands

Consist of 4 types of cells

- Mucous cells $\xrightarrow{\text{secrete}}$ mucus - protect inner lining of stomach by action of HCl
- Enteroendocrine cells
  - G-cells → Gastrin - stimulate the secretion of gastric juice
  - D-cells → Somatostatin
  - EC-cells → Serotonin - Vasoconstrictor
    → Histamine - Vasodilator
- Parietal cells (Oxyntic cells) → Castle Intrinsic Factor - helps in absorption of vitamin B_{12}
  → HCl (pH = 2 to 3) - (1) inactivate ptyaline
  (2) Kill bacteria present in bolus
  (3) Convert inactive enzymes into active enzymes
  (4) Provide acidic medium in stomach
  (5) Softens food particles
- (Peptic cells) Chief cells (Zymogen cells)
  - Gastric emylase (negligible role in starch digestion)
  - Gastric lipase - convert 1% emulsified fats already present in our food into fatty acids and glycerol
  - Pepsinogen → Pepsin — Proteins → *Proteoses + Peptones + Peptides*
  - Prorennin (In infants) $\xrightarrow{HCl}$ Rennin — *Soluble milk protein casein* → *Insoluble Ca-paracaseinate*

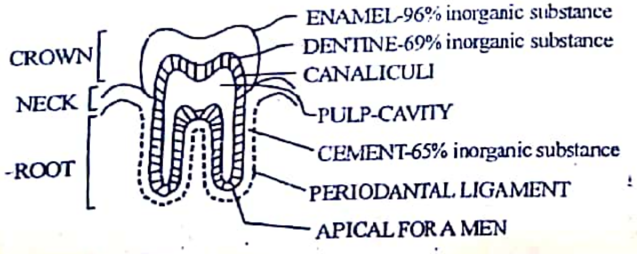
COMPARATIVE HISTOLOGY OF ALIMENTARY CANAL


MUCOSA
SUBMUCOSA
MUSCLES
L A M I N A M U S C U L A R I S
P R O P R I A
M U C O S A
NF
BV
LV
MP
OBLIQUE MUSCLES
MEISSNER'S PLEXUS
CIRCULAR MUSCLES
AUERBACH'S NERVE PLEXUS
LONGITUDINAL MUSCLES
SEROSA
Tunica adventia of white fibrous CT
SEROSA
When fats + lymph tissues are deposited called omentum
SEROSA
SEROSA
Villi
Crypts of Lieberkuhn
Panethcells
Peyers patches
Brunner's glands

- • GASTRIC GLANDS
- • • • MULTILAYERED EPITHELIUM

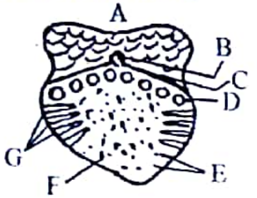
Blunt Villi are in duodenum whereas long and pointed in jejunum and ileum

STRUCTURE OF TOOTH :-

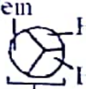

CROWN
NECK
ROOT
ENAMEL-96% inorganic substance
DENTINE-69% inorganic substance
CANALICULI
PULP-CAVITY
CEMENT-65% inorganic substance
PERIODANTAL LIGAMENT
APICAL FOR A MEN

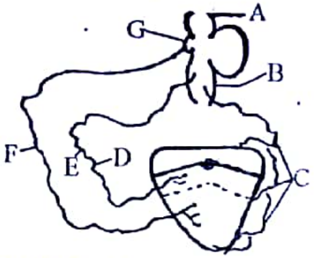
TONGUE

Highly muscular organ, present at the floor of oral cavity

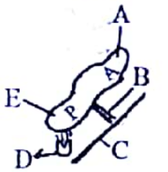


A –Pharyngeal part
B –Foramen Caecum
C –Sulcus Terminalis
D – Circumavallate Papilla
 -Largest in size
 -Least in number
 -Spherical shape
E – Filliform Papilla
 -Maximum in no.
 -Smallest in size
F – Fungiform Papilla
 -Mushroom shaped
G – Foliate Papilla
 -Leaf Like
 -Vestigeal


Branch of Hepatic Poral Vein
Branch of Hepatic Artery
Hepatic Ductule
Portal Triad

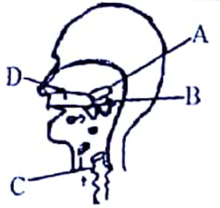


A –Midbrain (3, 4)
B –MO (9 to 12)
C –XII, Hypoglossal, movement of tongue
D – Taste, post. 1/3
E – IX Glossopharyngeal
F – VII Facial taste in ant. 2/3 rd



A –Extrinsic muscles
B –Frenulum lingua
C –Floor of oral cavity
D – Hyoid bone
E – Intrinsic muslces

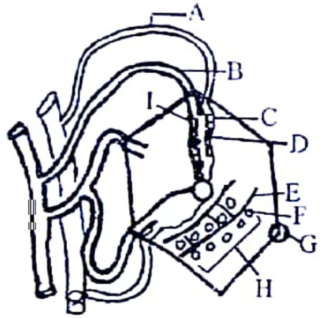
SWALLOWING-REFLEX



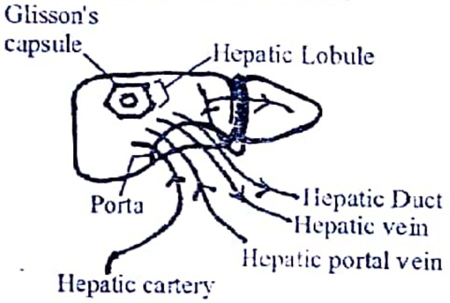
A –Uvula lift up and form a partition bw' 'np' and 'op'
B –Soft Palate (Made up of voluntary muscles and fibrous CT.)
C –Larynx lift up and epiglottis cover glottis
D – Hard Palate (Made up of palatine and maxilla) contain transverse ridges called PALATINE RUGAE.

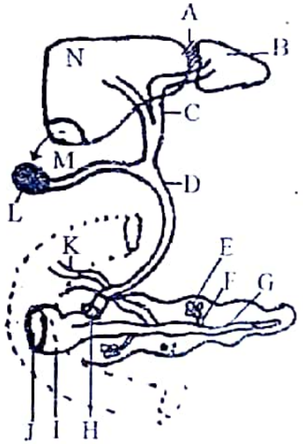
LIVER :

- Largest gland of our body.
- Endodermal in origin.
- Consist of two lobes-right and left



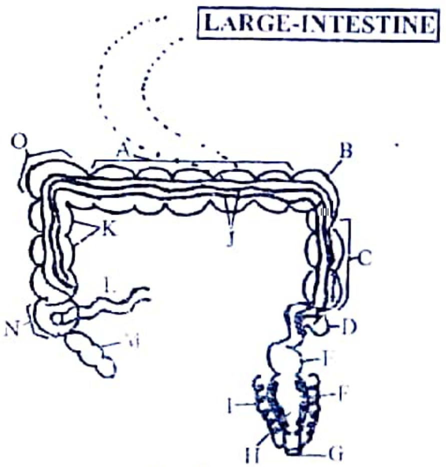
A –Branch of Heparic Portal vein
B –Branch of Hepatic Artery
C –Discontinuous endothelium
D –Kupffer cells (Phagocytic)
E –Bile canaliculi
F –Hepatocytes
G –Portal Triad
H –Hepatic cord
I –Sinusoid


Glisson's capsule
Hepatic Lobule
Porta
Hepatic Duct
Hepatic vein
Hepatic portal vein
Hepatic cartery


A
B
C
D
E
F
G
H
I
J
K
L
M
N

A –Falciformligament
B –Left lobe of liver
C –Hepatic Duct
D –Common Bile duct
E –Cells of Acini
F –Acinar Duct
G –Duct of Wirsung
H –Sphincter of Boyden
I –Hepatopancreatic ampulla
J –Sphincter of Oddi
K –Duct of Santorini
L –Gall Bladder
M –Cystic duct
N –Right lobe of liver 5/6

LARGE-INTESTINE


O
A
B
C
D
E
F
G
H
I
J
K
L
M
N

A –Transverse colon
B –Splenic plexure
C –Descending colon
D –Signoid colon
E –Rectum
F –Anal canal
G –Anus
H –Internal anal Sphincter (Involuntary)
I –External anal sphincter (Voluntary)
J –Taeniacoli
K –Haustra
L –Ileum
M –Vermiform appendix
N –Caecum

When chyme enter into doudenum HCL of chyme stimulate different enteroendocrine cells of intestine to secrete following hormones.

1. Secretin - 1st discovered hormone, stimulate pancreas to synthesise and secrete nonenzymatic part of pancreatic juice.
2. Pancreozymin stimulate pancreas to synthesise and secrete enzymatic part of pancreatic juice.
3. Hepatocrinin stimulate liver cells for synthesis and secretion of bile juice.
4. Cholecystokinin stimulate liver and Gall Bladder for secretion of bile juice.
5. Duocrinin stimulate Brunner's glands for synthesis and secretion of Intestinal juice's nonenzymatic part.
6. Enterocrinin stimulate paneth cells to synthesise and secrete enzymatic part of intestinal juice.
7. Villikinin stimulate the activity of villi.
8. Entrogasterone inhibit secretion of HCl in stomach.
9. Gastric Inhibitory polypeptide inhibit secretion of Gastrin hormone.
10. Vaso Active Intestinal Polypeptide decreases peristalsis in stomach and increases peristalsis in intestine.
11. Glucose dependent Insulinotropic Peptide is secreted by K cells of intestine and stimulate secretion of insulin from b cells of pancreas.

BILE-JUICE

– pH = 8.0, daily formed 500 to 800 ml.

– Pseudo digestive juice because donot contain any enzyme.

H_2O (98%)
Other (2%)

Bile pigments - Bilirubin (yellow) and Biliverdin (Green)

Inorganic - NaCL, Na_2CO_3, $NaHCO_3$ - provide alkaline medium in duodenum
Organic Bile Salts → Na glycolate, Na taurocholate → helps in emulsification of fats.

Other function of bile juice :

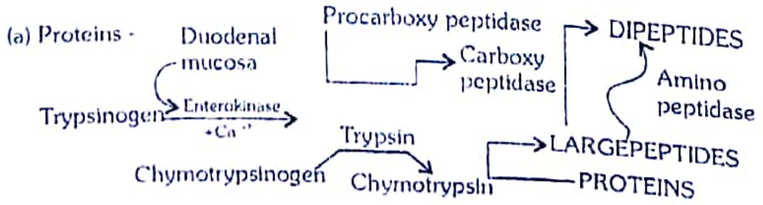
1. Active pancreatic lipase
2. Increase peristalsis in intestine
3. Neutralise the acidity of HCl
4. Prevent food from decomposition.
5. Helps in absorption of fats and fat soluble vitamins.

PANCREATIC JUICE - pH = 7.5 to 8.3, daily formed 1ℓ to 1.5 ℓ

Contain many enzymes which helps in digestion in duodenum.

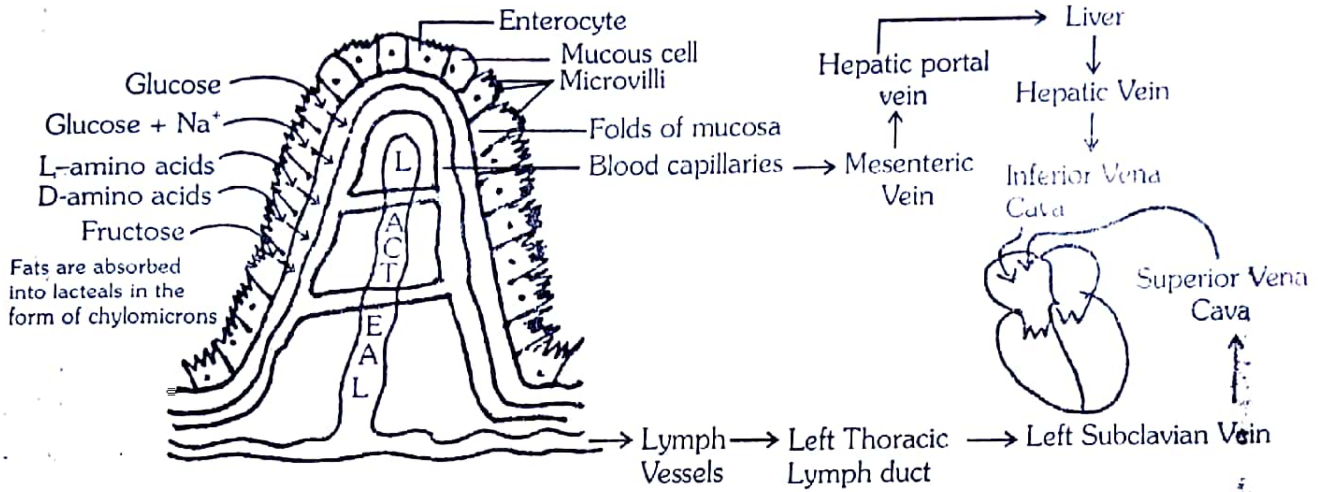
DIGESTION IN DUODENUM

1. Carbohydrates - Starch $\xrightarrow{\text{Pancreatic-amylage}}$ Maltos + α - Dextrin
2. Fats - (a) Phospholipids $\xrightarrow{\text{Phosphlipase}}$ PO_4^{3} + Lipids
   (b) Cholesterolesters $\xrightarrow{\text{Cholesterolestasase}}$ Cholesterol + esters
   (c) Triglycerides $\xrightarrow[\text{lipase}]{\text{Pancreatic}}$ Monoglycerides + Glycerol + Fatty Acids
3. DNA is digested by DNAase and RNA by RNase



ABSORPTION IN DUODENUM : In duodenum iron and calcium ions are absorbed.

ABSORPTION IN JEJUNUM : Maximum absorption of food takes place in jejunum.
(Fats does not follow entero hepatic circulation)


Enterocyte
Mucous cell
Microvilli
Folds of mucosa
Blood capillaries
Glucose
Glucose + Na$^+$
L-amino acids
D-amino acids
Fructose
Fats are absorbed into lacteals in the form of chylomicrons
L
ACTEAL
Hepatic portal vein
Liver
Hepatic Vein
Mesenteric Vein
Inferior Vena Cava
Superior Vena Cava
Lymph Vessels
Left Thoracic Lymph duct
Left Subclavian Vein

ABSORPTION IN ILEUM : Vitamin B_{12} and bile salts are absorbed

DIGESTION IN CAECUM : In human beings caecum and appendix both are vestigeal. In Rabbit both are functional. In caecum of Rabbit, cellulose is digested with the help of an enzyme cellulase by decomposition process. Digestion of cellulose is very slow process.

ABSORPTION IN COLON : Water is absorbed. Haustra increases surface area of colon for H_2O absorption

ASSIMILATION OF FOOD :

(1) **Proteins and amino acids -** Amino acids are not stored in body as they are highly reactive so converted into proteins which are building blocks of body. Excess of amino acids are converted into Glucose by Gluconeogenesis in liver. NH_3 is removed in this process and step is deamination. Deamination takes place in each and every cell of body but liver and kidney are chief sites of deamination.

(2) **Carbohydrates**
- Glucose is instant source of energy.
- Glucose ⟶ Glycogen in liver (Glycogenesis) (Glycogen in stored food material)
- Whenever required, Glycogen ⟶ Glucose (Glycogenolysis)
- Amino acids and fats ⟶ Glucose in liver (Gluco neogenesis)
- Lactic acid formed in muscles ⟶ Glycogen in liver by Glyconeogenesis

(3) **Fats -**
- Stored in body, help in insulation and thermoregulation
- Rich source of energy

(4) Minerals, water and vitamins plays vital role in many vital processes of body.

EGESTION : Undigested food material is stored in the form of faecal matter in rectum. Removal of faecal matter from body is called egestion. Faecal matter is yellowish brown in color due to the presence of two pigments (Stercobilin and Urobilin). These two are formed due to degradation of bile salts. Foul smell in excreta is due to the presence of CH_4, NH_3, indole, scatole, tryphtophan and H_2S.

- Rabbits faecal matter is in the form of pellets which contain more amount of cellulose in it Rabbit feed on its own faced matter in order to digest the extra amount of cellulose present in it this process is called coprophagy (pseudorumination).
- Rabbit's excreta donot have much smell as main component of excreta is cellulose.
- Carnivore's excreta have much smell as main component of excreta is protein

SUMMARY OF DIGESTIVE SYSTEM

HISTOLOGY	STRUCTURE OF ALIMENTARY CANAL	DESCRIPTION
	Mouth	Is an anterior opening with which alimentary canal begins
	Buccal cavity (Oral cavity)	Contain teeth and tongue **Teeth** are thecodont, diphyodont and heterodont. Four different types of teeth are incisors, canines, premolors and molars with dental formula in adults is 2123/2123 **Tongue** is highly muscular organ attached to floor of oral cavity by frenulum and contain papilla on upper surface, some papilla bear taste buds.
Intestine stomach Oesophagus **Serosa** outermost of mesothelium with some connective tissue. **Muscularis** of smooth muscles with outer longitudinal and inner circular **Submucosa** - of loose CT + nerves + blood vessels + lymph vessels. **Mucosa** - inner most contain goblet cells which secret mucus that help in lubrication. Exceptions **Oesophagus** multilayeted epithelium **Stomach** - Oblique muscles in muscularis, gastric gland in mucosa. **Small intestine** - mucosa contain villi cells lining villi produce numerous microscopic projection called microvill Contain Brunner's glands in submucosa Villi are supplied with a network of capillaries and a large lymph vessel called lacteal	**Pharynx**	Common passage for food and air Contain two openings (1) Ventral glottis (Epiglottis) Trachea (Wind pipe) (2)Dorsal Gullet Oesophagus (Food pipe) Gastroesophageal sphincter
	Stomach (J-shaped)	**Cardiac** → **Fundus** (middle part) → **Pylorus** Pyloric sphincter
	Small intestine	**Duodenum** - U-shaped **Jejunum** - middle part **Ileum** - highly coiled, last part of small intestine
	Large intestine	**Caecum** - Small blind sac, hosts some symbiotic microorganism **Colon** - Ascending, transverse, descending **Rectum** - opens into anus

GLANDS, THEIR SECRETION AND PHYSIOLOGY

Saliva ← Secrete — Oral cavity contain 3 pairs of salivary glands
1.Parotids (Cheek)
2.Submaxillary (lower jaw)
3.Sublingual (below tongue)

Contain
Mucus - (helps in lubricating and adhering the masticated food particles into a bolus)
Electrolytes (Na^+, K^+, Cl^-, HCO_3^-)
Lysozyme (antibacterial)

Ptyalin (Salivary amylase) — Starch (~ 30%), pH = 6.8 → Maltose

Food + Saliva = Bolus

Liver (Largest gland of body) (Wt. 1.2 to 1.5 kg) (Situated in abdominal cavity just below diaphragm) (Contain 2 lobes) — Secrete → **Bile**
Bile — Contain → Bile pigment (Bilirubin + Biliverdin)
→ Bile salts, cholesterol, phospho lipids (Enzymes absent)
Bile helps in → emulsification of fats, activates lipases

Liver — Hepaticduct; **Gallbladder** (hellp in concentration and storage of bile) — Cystic duct; → Common bileduct → Hepatopancreatic ampulla with sphincter of oddi → **Duodenum**

Pancreas (Compound elongated organ) — Pancreatic duct → **Duodenum**

Pancreas — Secrete → Pancreatic juice — Contain inactive enzymes
→ Trypsinogen
→ Chymotrypsinogen Chymotrypsin
→ Amylases
→ Lipases
→ Nucleases
→ Procarboxy peptideses → Carboxypeptideses

Trypsinogen — Enterokinase → Trypsin (Activate enzymes inpancreatic juice)

Proteins, Peptones, Proteases → Dipeptides

Pancreas — Secrete → Alkaline pancreatic juice by exocrine portion
→ Hormones (insulin + glucogan) by endocrine portion

Emuisified fats — Pancreatic lipase → Fatty acids + Glycerol
Starch — Pancreatic amylase → Maltose

Secretions and functions of intestinal juice
Sucrose — Sucrase → Glucose + Fructose
Lactose — Lactase → Glucose + Galactose
Maltose — Maltase → Glucose + Glucose
Fats — Lipases → Diglycerids → Monoglycerids
Nucleic acids — Nucleases → Nucleotides → Nucleosides

Gastric glands — **Cells**
Mucous (neck) → Mucus
Peptic (chief) → Pepsinogen — HCl → Pepsin
Protein → Proteases + peptones
→ Prorennin — HCl → Rennin (hellp in digestion of milk protein in infants)
→ Small amount of gastric lipase,
Parietal (Oxyntic) → intrinsic factor help in absorption of vitamin-B_{12}
→ HCl provide acidic medium, inactivate ptyalin, activate pro-enzymes

BREATHING AND EXCHANGE OF GASES

- The process of exchange of O_2 from the atmosphere with CO_2 produced by the cells is called breathing, commonly known as respiration.

S.No.	Respiratory organs	Examples
1	General body surface	Sponges, Coelenterates, Flat worms
2	Moist skin	Earthworms, Frogs
3	Tracheal tubes	Insects
4	Gills	Aquatic arthropods, Molluscs, Fishes
5	Lungs	Reptiles, Birds, Mammals

- Pharynx is the common passage for food and air.
- In human, path of air is :

External nostrils → Nasal chamber → Nasopharynx → Larynx → Trachea → Primary Bronchi

Alveoli ← Bronchioles network ← Tertiary bronchi ← Secondary Bronchi

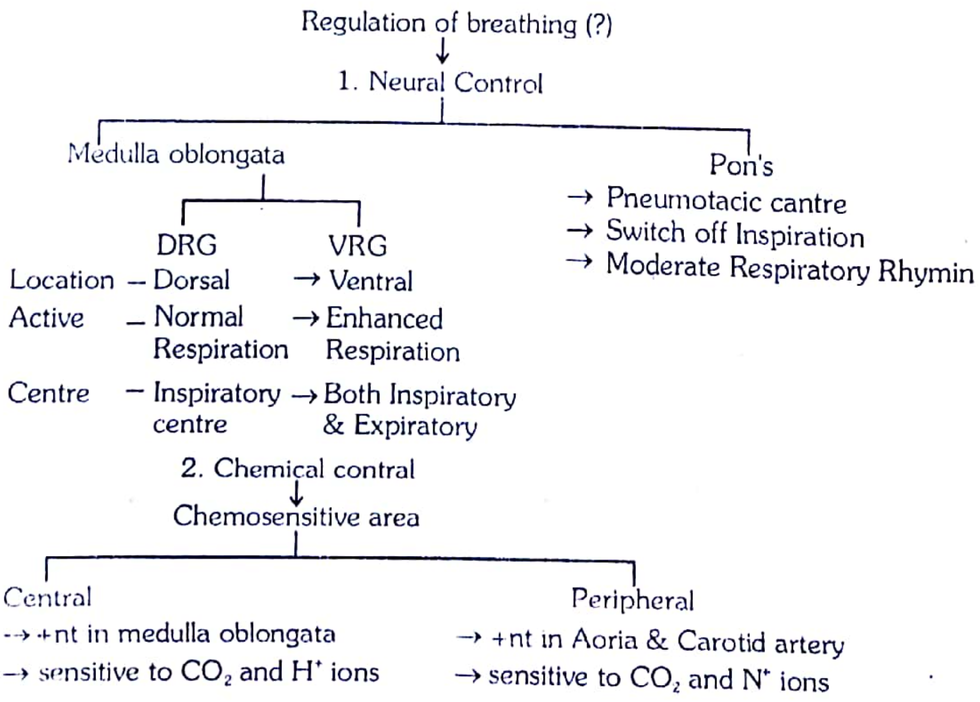
- Inspiration can occur if the pressure within the lungs (intra-pulmonary pressure) is less than the atmospheric pressure. Inspiration is initiated by the contraction of diaphragm and external inter costal muscles (EICM).

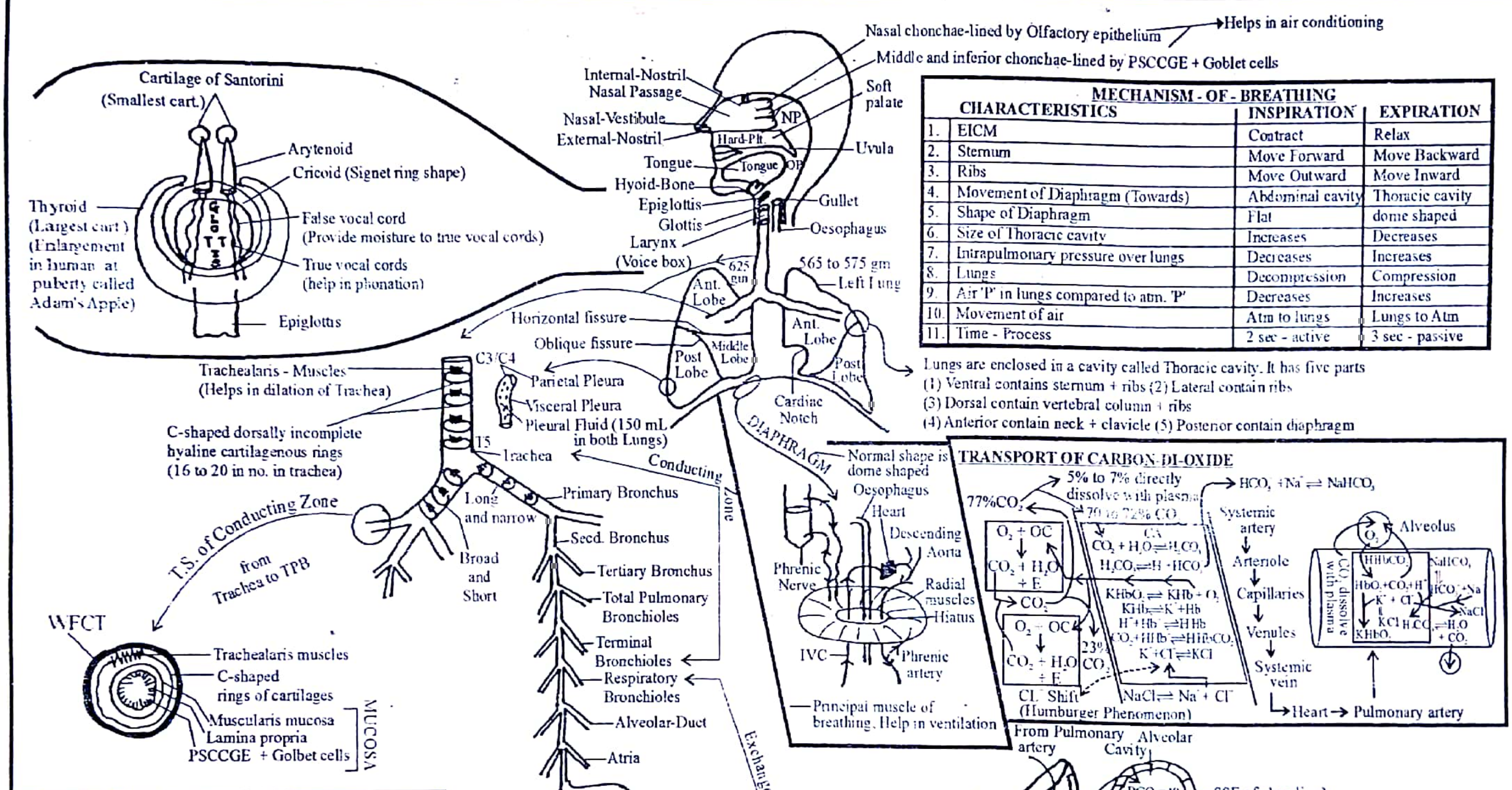
  Expiration takes place when the intrapulmonary pressure more than the atmospheric puressure. In this diaphragm and EICM are relaxed.
- Alveoli are the primary sites of exchange of gases. Exchange of gases also occur between blood and tissues. O_2 and CO_2 are exchanged in these sites by simple diffusion mainly based on pressure/concentration gradient.
- **Partial pressures (in mm Hg) of oxygen and carbon dioxide.**

Respiratory Gas	Atmospheric Air	Alveoli	Deoxygenated blood	Oxygenated blood	Tissues
O_2	159	104	40	95	40
CO_2	0.3	40	45	40	45

S.No.	Respiratory volumes and capacities	Value
1	Tidal volume (TV)	500 ml
2	Inspiratory reserve volume (IRV)	2500-3000 ml
3	Expiratory reserve volume (ERV)	1000-1100 ml
4	Residual volume (RV)	1100-1200 ml
5	Inspiratory capacity (TV + IRV)	3500 ml
6	Expiratory capacity (TV + ERV)	1600 ml
7	Functional residual capacity (ERV + RV)	2300 ml
8	Vital capacity (TV + IRV + ERV)	4600 ml
9	Total lung capacity (TV + IRV + ERV + RV)	5800 ml

- Blood transport O_2 in the form of oxyhaemoglobin. O_2 can bind with heamoglobin in a reversible manner to form oxyhaemoglobin. Each haemoglobin molecule can carry a maximum of four molecules of O_2. Binding of oxygen with haemoglobin is primarily related to partial pressure of O_2.
- Oxygen dissociation curve is sigmoid.
- High PO_2 low PCO_2, lesser H^+ concentration and lower temperature, the factors are all favourable for the formation of oxyhaemoglobin.
- Every 100 ml of oxygenated blood can deliver around 5 ml of O_2 to the tissues.
- CO_2 is transporeted by blood in three forms :
  - (i) Carbamino - haemoglobin (about 20-25%)
  - (ii) Bicarbonate - (about 70%)
  - (iii) Dissolved in plasma (about 7%)
- Every 100 ml of deoxygenated blood delivers approximately 4 ml of CO_2 to the alveoli.
- Respiratory rhythm centre present in the medulla region and pneumotaxic centre present in the pons region.
- Asthma is due to inflammation of bronchi and bronchioles.
- In Emphysema alveolar wall are damaged so respiratory surface is decreased.


Regulation of breathing (?)
1. Neural Control
Medulla oblongata
Pon's
→ Pneumotacic cantre
→ Switch off Inspiration
→ Moderate Respiratory Rhymin
DRG
VRG
Location – Dorsal → Ventral
Active – Normal Respiration → Enhanced Respiration
Centre – Inspiratory centre → Both Inspiratory & Expiratory
2. Chemical contral
Chemosensitive area
Central
→ +nt in medulla oblongata
→ sensitive to CO₂ and H⁺ ions
Peripheral
→ +nt in Aoria & Carotid artery
→ sensitive to CO₂ and N⁺ ions

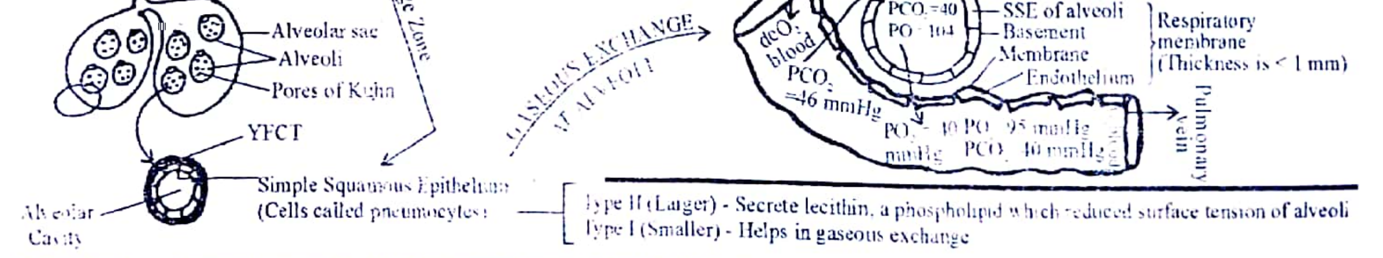

Cartilage of Santorini
(Smallest cart.)
Arytenoid
Cricoid (Signet ring shape)
Thyroid
(Largest cart.)
(Enlargement in human at puberty called Adam's Apple)
False vocal cord
(Provide moisture to true vocal cords)
True vocal cords
(help in phonation)
Epiglottis
Nasal chonchae-lined by Olfactory epithelium → Helps in air conditioning
Middle and inferior chonchae-lined by PSCCGE + Goblet cells
Internal-Nostril
Nasal Passage
Nasal-Vestibule
External-Nostril
NP
Hard-Plt.
Tongue
OP
Soft palate
Uvula
Tongue
Hyoid-Bone
Epiglottis
Glottis
Larynx
(Voice box)
Gullet
Oesophagus
625 gm
565 to 575 gm
Left Lung
Ant. Lobe
Middle Lobe
Post Lobe
Ant. Lobe
Post Lobe
Cardiac Notch
Horizontal fissure
Oblique fissure
Parietal Pleura
Visceral Pleura
Pleural Fluid (150 mL in both Lungs)
C3/C4
T5
Trachealis - Muscles
(Helps in dilation of Trachea)
C-shaped dorsally incomplete hyaline cartilagenous rings
(16 to 20 in no. in trachea)
Trachea
Conducting Zone
Primary Bronchus
Long and narrow
Broad and Short
Secd. Bronchus
Tertiary Bronchus
Total Pulmonary Bronchioles
Terminal Bronchioles
T.S. of Conducting Zone
from Trachea to TPB
WFCT
Trachealaris muscles
C-shaped rings of cartilages
Muscularis mucosa
Lamina propria
PSCCGE + Golbet cells
MUCOSA
DIAPHRAGM
Normal shape is dome shaped
Oesophagus
Heart
Descending Aorta
Phrenic Nerve
Radial muscles
Hiatus
IVC
Phrenic artery
Principal muscle of breathing, Help in ventilation

	CHARACTERISTICS	INSPIRATION	EXPIRATION
1.	EICM	Contract	Relax
2.	Sternum	Move Forward	Move Backward
3.	Ribs	Move Outward	Move Inward
4.	Movement of Diaphragm (Towards)	Abdominal cavity	Thoracic cavity
5.	Shape of Diaphragm	Flat	dome shaped
6.	Size of Thoracic cavity	Increases	Decreases
7.	Intrapulmonary pressure over lungs	Decreases	Increases
8.	Lungs	Decompression	Compression
9.	Air 'P' in lungs compared to atm. 'P'	Decreases	Increases
10.	Movement of air	Atm to lungs	Lungs to Atm
11.	Time - Process	2 sec - active	3 sec - passive

Lungs are enclosed in a cavity called Thoracic cavity. It has five parts
(1) Ventral contains sternum + ribs (2) Lateral contain ribs
(3) Dorsal contain vertebral column + ribs
(4) Anterior contain neck + clavicle (5) Posterior contain diaphragm

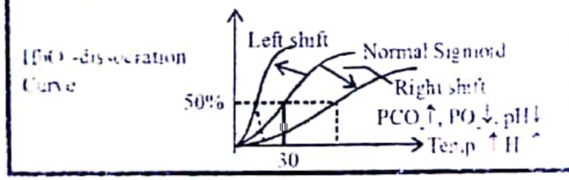
TRANSPORT OF CARBON-DI-OXIDE

77%CO₂
5% to 7% directly dissolve with plasma
70 to 72% CO₂
O₂ + OC
CO₂ + H₂O + E
CO₂
O₂ + OC
CO₂ + H₂O + E
23% CO₂
CA
CO₂ + H₂O ⇌ H₂CO₃
H₂CO₃ ⇌ H⁺ + HCO₃⁻
HCO₃⁻ + Na⁺ ⇌ NaHCO₃
KHbO₂ ⇌ KHb + O₂
KHb ⇌ K⁺ + Hb
H⁺ + Hb⁻ ⇌ H Hb
CO₂ + HHb ⇌ HHbCO₂
K⁺ + Cl⁻ ⇌ KCl
NaCl ⇌ Na⁺ + Cl⁻
Cl⁻ Shift
(Humburger Phenomenon)
Systemic artery
Arteriole
Capillaries
Venules
Systemic vein
Heart → Pulmonary artery
Alveolus
O₂
CO₂ dissolve with plasma
HHbCO₂
HbO₂ + CO₂ + H⁺
K⁺ + Cl⁻
KCl
KHbO₂
NaHCO₃
HCO₃⁻ + Na
NaCl
H₂CO₃ ⇌ H₂O + CO₂


Respiratory Bronchioles
Alveolar-Duct
Atria
Exchange Zone
Alveolar sac
Alveoli
Pores of Kuhn
YFCT
Simple Squamous Epithelium
(Cells called pneumocytes)
Alveolar Cavity
Type II (Larger) - Secrete lecithin, a phospholipid which reduced surface tension of alveoli
Type I (Smaller) - Helps in gaseous exchange
GASEOUS EXCHANGE AT ALVEOLI
From Pulmonary artery
Alveolar Cavity
deO₂ blood
PCO₂ = 46 mmHg
PCO₂ = 40
PO₂ = 104
PO₂ = 40 mmHg
PO₂ = 95 mmHg
PCO₂ = 40 mmHg
SSE of alveoli
Basement Membrane
Endothelium
Respiratory membrane
(Thickness is < 1 mm)
Pulmonary vein

O_2 TRANSPORT :

- Out of the total O_2 inhaled only 3% dissolve in plasma whereas 97% of O_2 + Hb → HbO_2
- With one molecule of Hb, 4 molecules of O_2 combines
- 100 mL of blood transport 20 mL of O_2, out of which 5mL is liberated at tissue level



- If CO_2 Concentration increases in blood, breathing rate increases
- In human beings negative pressure breathing is present
- In frog, positive pressure breathing is present

BODY FLUIDS AND CIRCULATION

1. Two types of circulatory patterns are :

	Open		Closed
(a)	Blood flows through open spaces called sinuses.	(a)	Blood flows through closed network of blood vessels.
(b)	e.g. Arthropods, Molluscs	(b)	e.g. Annelids, Vertebrates

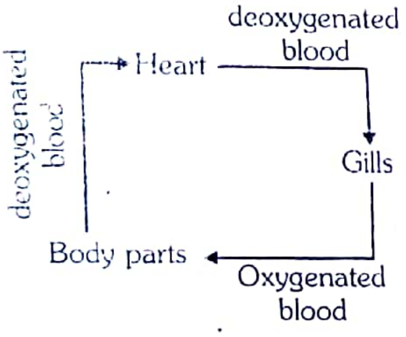
2. All vertebrates possess a muscular chambered heart :

	Fishes	Amphibians	Reptiles	Crocodile	Birds	Mammals
Number of chambers	2	3	3	4	4	4
Atria	1	2	2	2	2	2
Ventricles	1	1	1	2	2	2

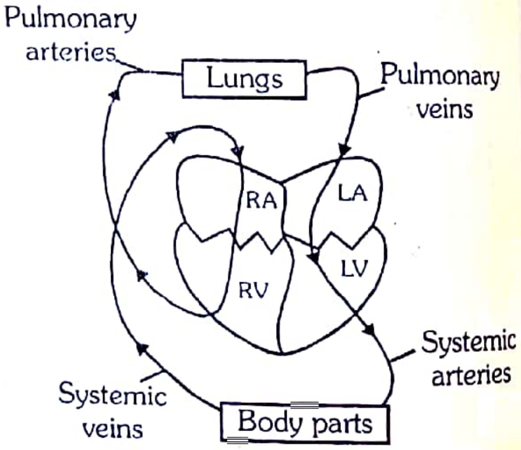
3. Single circulation in fishes

Incomplete double circulation in Amphibians and Reptiles

Complete double cirulation in Crocodile, Aves Mammals


deoxygenated blood
Heart
deoxygenated blood
Gills
Body parts
Oxygenated blood

Mixing of blood in ventricle/s of heart


Pulmonary arteries
Lungs
Pulmonary veins
RA
LA
RV
LV
Systemic arteries
Systemic veins
Body parts

4. **Human circulatory sytem** = heart + blood vessels + blood

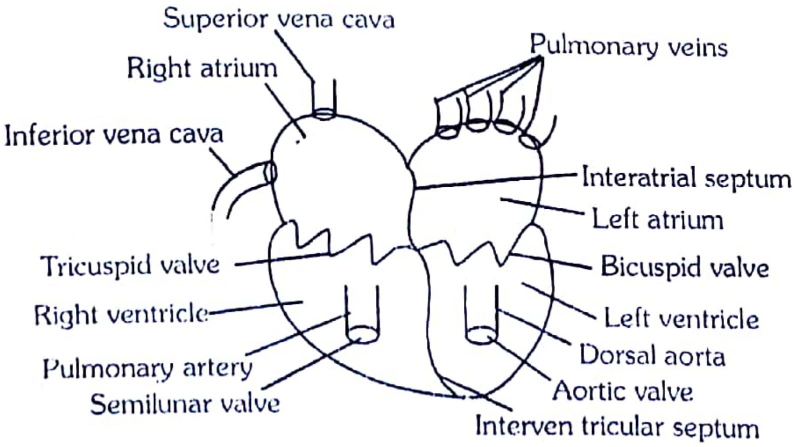
5. **Human heart :**

   (a) **Origin :** mesodermal

   (b) **Position :** Situated in the thoracic cavity, in between the two lungs, slightly tilted to the left.

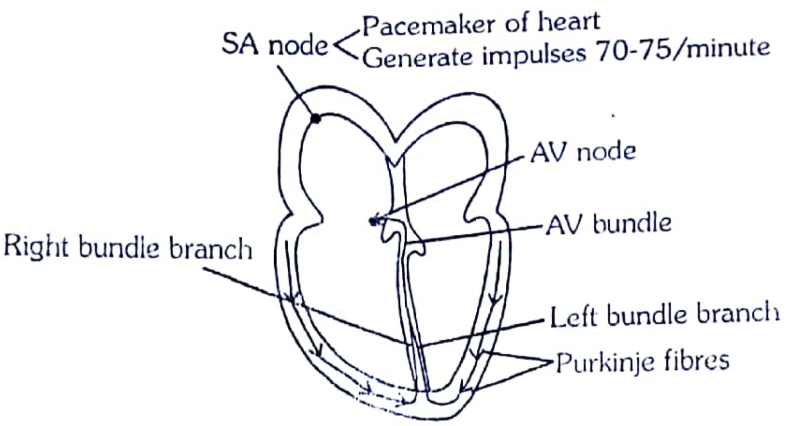
   (c) **Covering :** double walled pericardium.

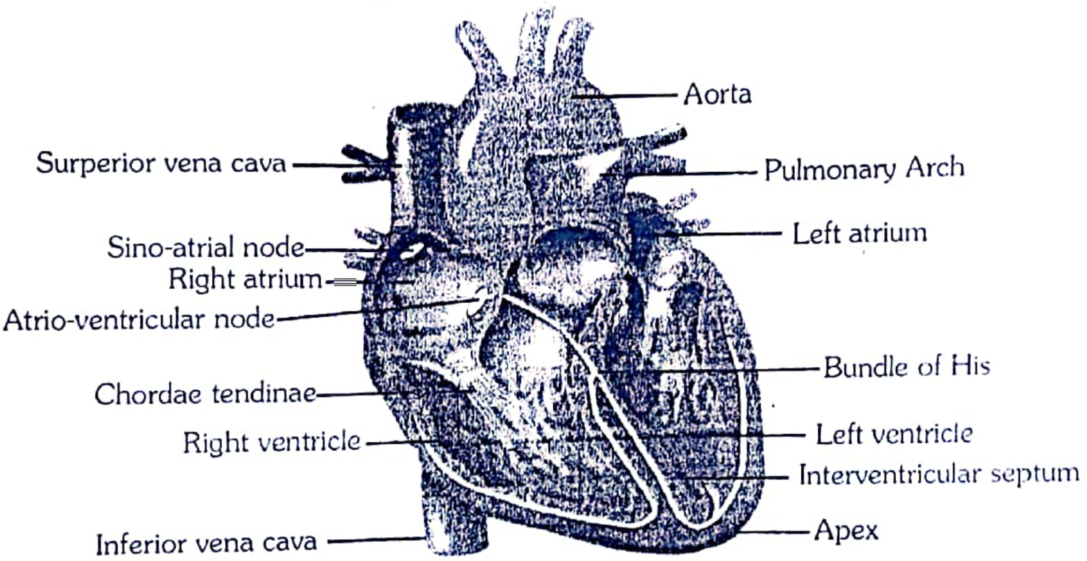
   (d) **Structure :**


Superior vena cava
Right atrium
Pulmonary veins
Inferior vena cava
Interatrial septum
Left atrium
Tricuspid valve
Bicuspid valve
Right ventricle
Left ventricle
Pulmonary artery
Dorsal aorta
Semilunar valve
Aortic valve
Interven tricular septum

Significance of valves : Valves prevent the backward flow of blood

(e) Conducting system of heart :

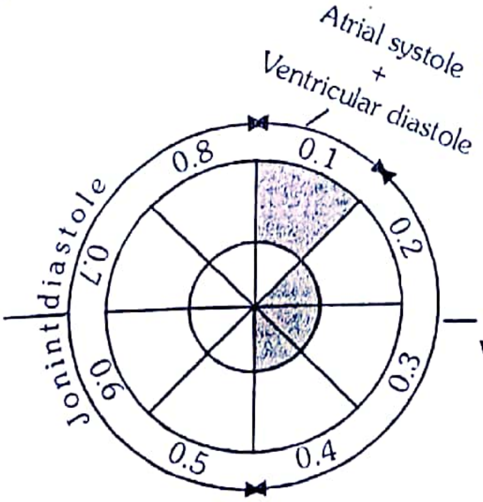

SA node
Pacemaker of heart
Generate impulses 70-75/minute
AV node
AV bundle
Right bundle branch
Left bundle branch
Purkinje fibres


Aorta
Surperior vena cava
Pulmonary Arch
Left atrium
Sino-atrial node
Right atrium
Atrio-ventricular node
Bundle of His
Chordae tendinae
Left ventricle
Right ventricle
Interventricular septum
Inferior vena cava
Apex

Section of a human heart

6. **Cardiac cycle :** Sequential events in the heart which is cyclically repeated called cardiac cycle.

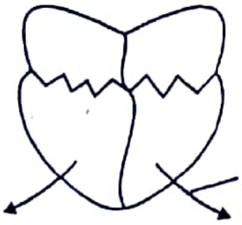
- Time of cardiac cycle = 0.8 second.


Atrial systole
+
Ventricular diastole
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Jonint diastole

SA node generate action potential, both atria contract, ↑ the flow of blood into ventricle by about 30%

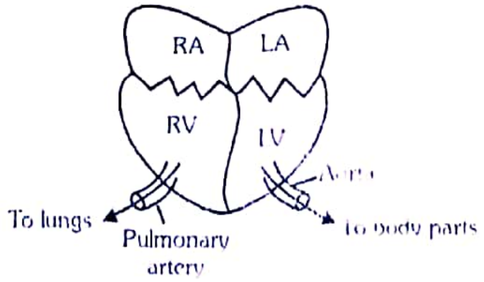
AV valves open, blood from pulmonary veins and vena cava flows into the left and right ventricle respectively through atria. Semiluar valves are closed

Atrial diastole + Ventricular systole — Closure of AV valves, opening of semilunar valves



70 mℓ in one cardiac cycle **Stroke volume**

Cardiac output = Stroke volume × heart rate
= 70 × 72 ≃ 5040 mℓ ≃ 5ℓ


RA
LA
RV
LV
Aorta
To lungs
Pulmonary artery
To body parts

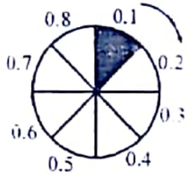
CARDIAC-CYCLE : The serial wise events which takes place in the heart constitute cardiac cycle

$$\text{Time of Cardiac Cycle} = \frac{1}{\text{Heart beat/minute}} \quad \text{i.e. Human beings} = \frac{60}{75} = 0.8\ \text{sec.} \quad \text{Canary bird} = \frac{60}{1000} = 0.06\ \text{sec.}$$

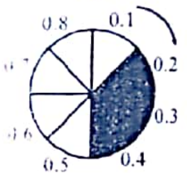
Events of Cardiac Cycle

- Systole
  - Atrial – 0.1 sec
  - Ventricular – 0.3 sec
- Diastole
  - Atrial – 0.7 sec
  - Ventricular – 0.5 sec

Atria

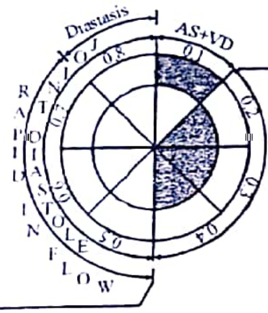

0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

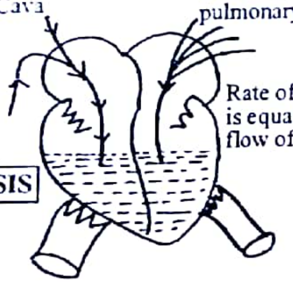
Ventricle


0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

Shaded Part – Systole
Non-shaded Part – Diastole

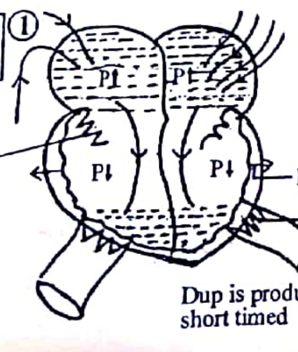
To begin with, all the four chambers of heart are in a relaxed state, i.e., they are in joint diastole. As the tricuspid and bicuspid valves are open, blood from the pulmonary veins and vena cava flows into the left and right ventricle respectively through the left and right atria. The semilunar valves are closed at this stage.


Diastasis
AS+VD
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
JOINT DIASTOLE
RAPID INFLOW

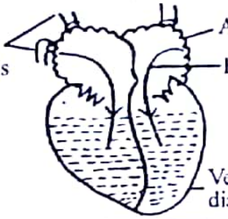

Blood from Vena Cava
Blood from pulmonary veins
Rate of filling of ventricles is equal to the rate of flow of blood in atria

DIASTASIS ②

RAPID IN FLOW ①


P↑
P↑
P↓
P↓
Opening of AV valves
Diastole begin
Closing of semilunar valves due to which second heart sound
Dup is produced which is sharp and short timed

The SA node now generates an action potential which stimulates both the atria to undergo a simultaneous contraction - the atrial systole. This increases the flow of blood into the ventricles by about 30 percent


flow of blood from veins into atria stops
Atrial systole
Blood from musculi pectinati
Comb like muscles in the walls of atria
Ventricular diastole

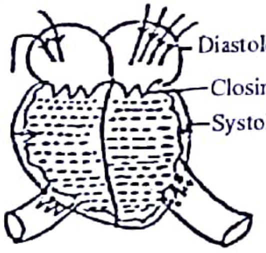
ATRIAL SYSTOLE – VENT. DIASTOLE ③

The action potential is conducted to the ventricular side by the AVN and AV bundle from where the bundle of His transmitts it through the entire ventricular musculature. This causes the ventricular musculature to contract (ventricular systole), the atria undergoes relaxation (diastole), coinciding with the ventricular systole. Ventricular systole increases the ventricular pressure causing the closure of tricuspid and bicuspid valves due to attempted back flow of blood into the atria (Isovolumetric contraction).

AD + P↑ – Both the atria are almost completely filled

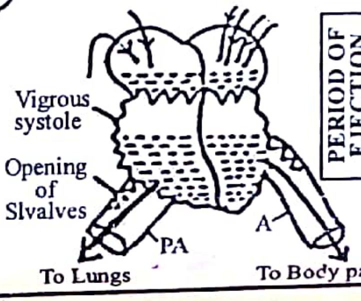
VS → Both the ventricles are almost 60% emptied + P↑

④

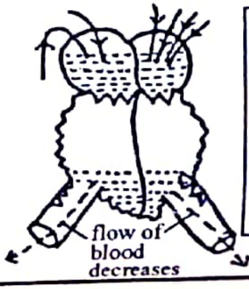

Diastole
Closing of valves
Systole begins

Isovolumetric Contraction

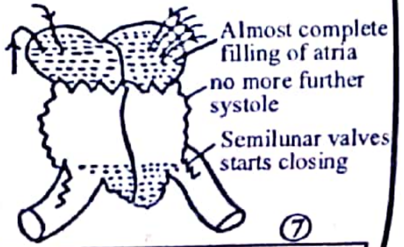
As the ventricular pressure increases further, the semilunar valves guarding the pulmonary artery (right side) and the aorta (left side) are forced open, allowing the blood in the ventricles to flow through these vessels into the circulatory pathways.


Vigrous systole
Opening of Slvalves
PA
A
To Lungs
To Body parts

PERIOD OF EJECTION ⑤

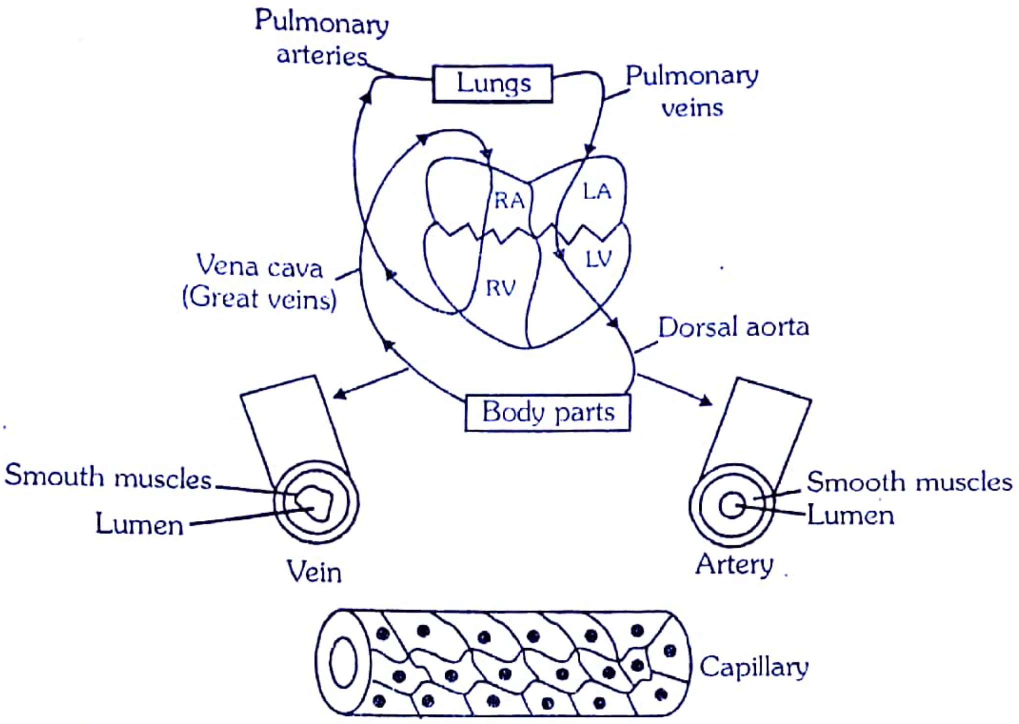

flow of blood decreases

PROTO DIASTOLE ⑥


Almost complete filling of atria
no more further systole
Semilunar valves starts closing

⑦ **ISOVOLUMETRIC-RELAXATION**

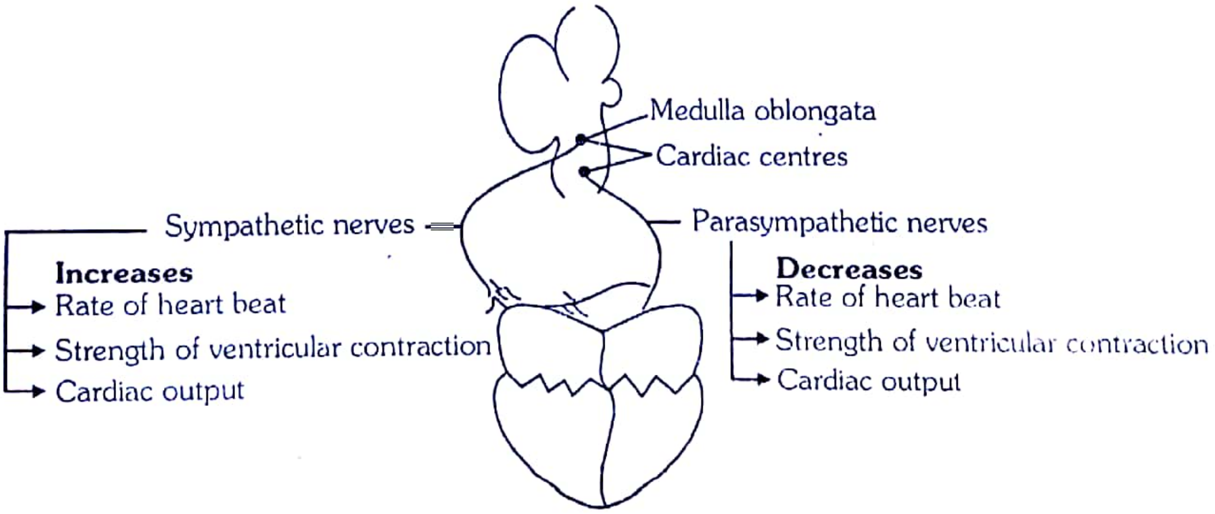
8. **Double circulation :**


Pulmonary arteries
Lungs
Pulmonary veins
RA
LA
RV
LV
Vena cava (Great veins)
Dorsal aorta
Body parts
Smooth muscles
Lumen
Vein
Smooth muscles
Lumen
Artery
Capillary

9. **Hepatic portal system :**

Digestive tract $\xrightarrow[\text{Vein}]{\text{Hepatic portal}}$ Liver $\longrightarrow$ Systemic Circulation

10. **Regulation of cardiac activity :** Human heart is myogenic


Medulla oblongata
Cardiac centres
Sympathetic nerves
Parasympathetic nerves

Increases
- Rate of heart beat
- Strength of ventricular contraction
- Cardiac output

Decreases
- Rate of heart beat
- Strength of ventricular contraction
- Cardiac output

11. **Disorders of circulatory system :**

(a) High blood pressure (Hypertension) :
- Normal BP is 120/80 mm of Hg
- 120 is systolic pressure.
- 80 is diastolic pressure.
- If BP increases more than 140/90 mm of Hg than called hypertension.

(b) Coronary heart disease : often referred to as atherosclerosis. Caused by deposition of Ca^{+2}. Fats, cholesterol and fibrous tissues in arteries.

(c) Angina pectoris is pain in heart muscles.

(d) Heart failure is the condition when heart is not pumping blood effectively to meet the needs of the bod

(e) Cardiac arrest : Heart stops beating.

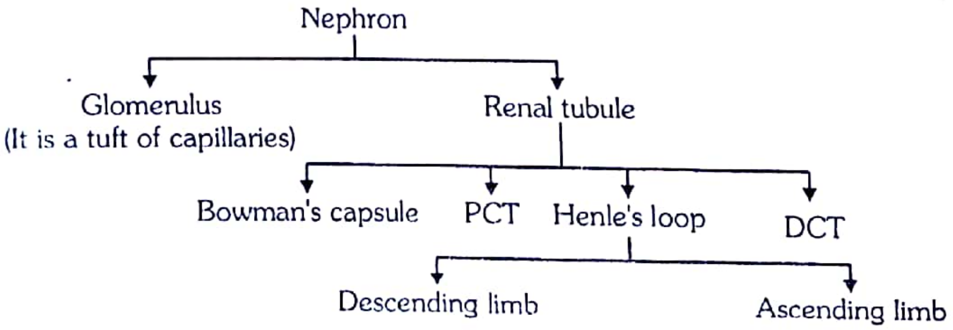
(f) Heart attack : Death of heart muscles due to an inadequate blood supply.

EXCRETORY PRODUCTS AND THEIR ELIMINATION

- Ammonia, Urea and Uric acid are the major forms of nitrogenous wastes excreted by the animals.
- Toxicity sequence = Ammonia > Urea > Uric acid.
- Ammonotelic animals = Many bony fishes, aquatic amphibains, aquatic insects.
- Ureotelic animals = Mammals, Marine fishes, terrestrial amphibians.
- Uricotelic animals = Reptiles, birds, insects, land snails.
- A survey of animal kingdom presents a variety of excretory structures.

S.No.	Excretory structures	Examples
1	Protonephridia (Flame cells)	Platyhelminthes, Rotiferes, Some annelids and Cephalochordate (*Amphioxus*).
2	Nephridia	Earthworms and other annelids
3	Malpighian tubules	Most insects
4	Antennal/Green glands	Crustaceans (Prawn)
5	Vertebrates	Kidney

- In humans, the excretory system consists of a pair of kidneys, one pair of ureters, a urinary bladder and a urethra.
- The outer layer of kidney is a tough capsule. Inside the kidney, there are two zones, an outer cortex and an inner medulla. The medulla is divided into a few conical masses (medullary pyramids) projecting into the calyces. The cortrex extends in between the medullary pyramids as renal columns called "Columns of Bertini".
- Each kidney has nearly one million complex tubular structures called nephrons which are the functional units.



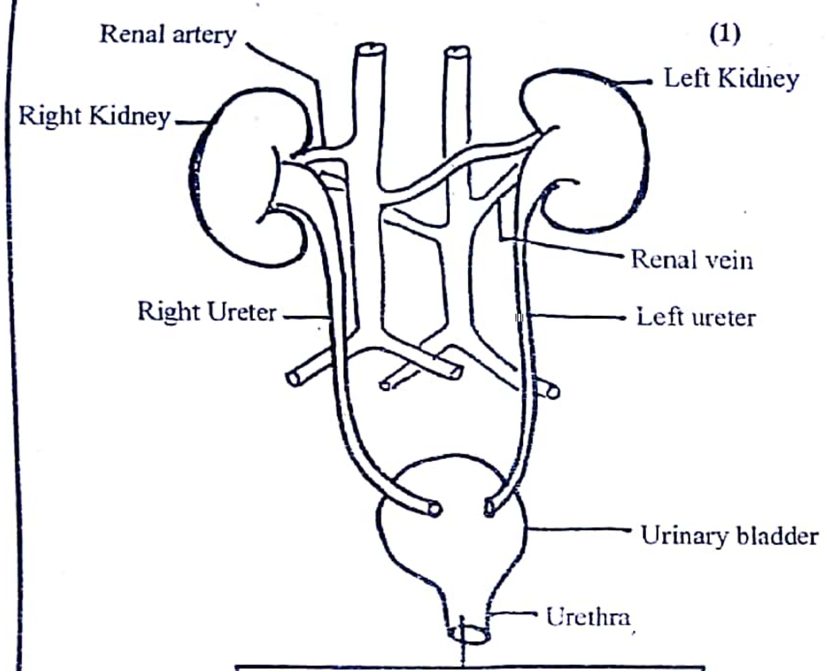
- Glomerulus + Bowman's capsule = Malpighian body or Renal corpuscle.
- The malpighian corpuscle, PCT and DCT of the nephron are situated in the cortical region of the kidney whereas the loop of Henle dip into the medulla.

Type of Nephron

Cortical nephron	Juxta medullary nephron
Loop of Henle is too short	Loop of Henle is very long
Vasa recta is absent	Vasa recta is a present
85% of total nephron	15% of total nephron

HUMAN EXCRETORY SYSTEM consist of

(1)

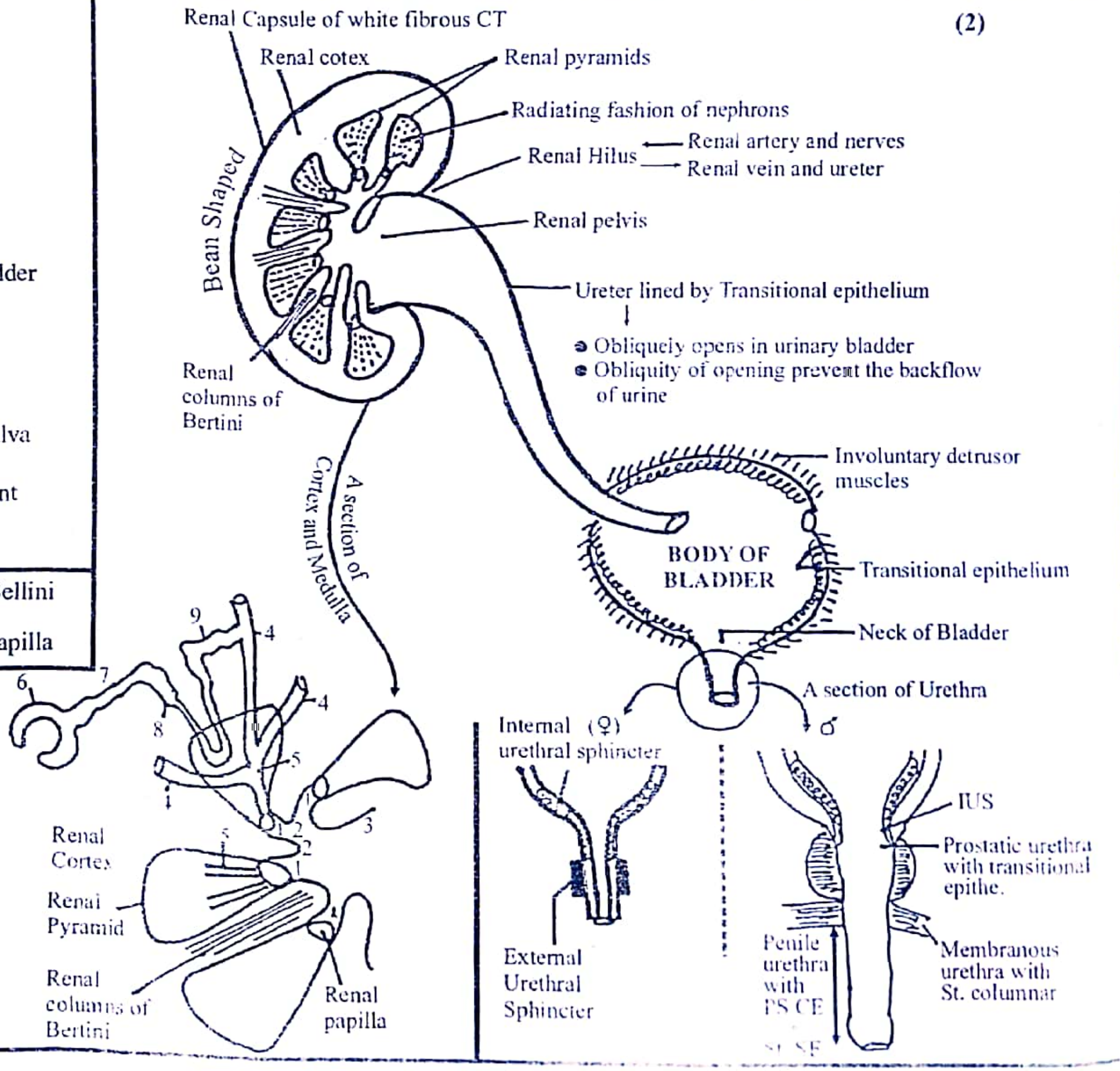

Renal artery
Right Kidney
Left Kidney
Renal vein
Right Ureter
Left ureter
Urinary bladder
Urethra

- In ♂ opens into penis
- Parts of ♂ urethra
  - Prostatic
  - Membranous
  - Penile
- In ♀ opens into vulva
- Parts of ♀ urethra
  - Prostatic - absent
  - Membranous
  - Penile - absent

1. One pair of Kidneys
2. One pair of Ureters
3. One urinary bladder
4. One urethra
5. Renal vessels - renal artery and renal vein

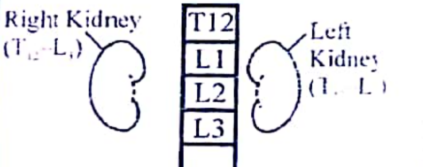
- Renal artery carry oxygenated blood towards Kidney.
- Renal vein carry deoxygenated blood away from Kidney.

(2)


Renal Capsule of white fibrous CT
Renal cotex
Renal pyramids
Radiating fashion of nephrons
Renal Hilus
Renal artery and nerves
Renal vein and ureter
Renal pelvis
Bean Shaped
Renal columns of Bertini
Ureter lined by Transitional epithelium
Obliquely opens in urinary bladder
Obliquity of opening prevent the backflow of urine
Involuntary detrusor muscles
BODY OF BLADDER
Transitional epithelium
Neck of Bladder
A section of Urethra
A section of Cortex and Medulla
Internal (♀) urethral sphincter
External Urethral Sphincter
♂
IUS
Prostatic urethra with transitional epithe.
Membranous urethra with St. columnar
Penile urethra with PS CE
St. SE
1
2
3
4
5
6
7
8
9
Renal Cortex
Renal Pyramid
Renal columns of Bertini
Renal papilla

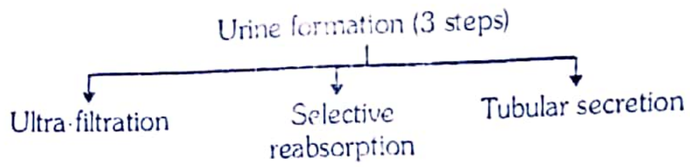
PASSAGE OF URINE Nephron → Collecting duct → Duct of Bellini → Renal Papilla → Renal Calyx → Renal Pelvis → Ureters → Urinary bladder → Urethra (3)

POSITION OF KIDNEYS IN BODY (4)


Right Kidney (T_{12}-L_3)
T12
L1
L2
L3
Left Kidney (T_{12}-L_3)

- On dorsal side of the body
- Human Kidneys are retroparietoneal as ventral part of kidneys are lined by visceral peritoneum

6. Bowman's capsule
7. PCT
8. Loop of Henle
9. DCT
4. Collecting duct
5. Duct of Bellini
1. Minor calyx
2. Major calyx
3. Renal pelvis



- Glomerular filtration takes place in Bowman's capsule and glomerular filtrate is formed which is protein les plasma.
- On an average 1100-1200 ml of blood is filtered by the kidney per minute.
- Glomerular filtration rate (GFR) in a healthy individual is 125 ml/minute or 180 litres per day.
- Nearly 99 percent of the filtrate has to be reabsorbed by the renal tubules. This process is called reabsorption
- Substances like glucose, amino acids, Na^+ etc. in the filtrate are reabsorbed actively whereas the nitrogenous wastes and water are absorbed by passive transport.
- During urine formation, the tubular cells secrete substances like H^+, K^+ and ammonia into the filtrate. This tubular secretion is an active process.
- **Functions of the tubules :**

1. **PCT :**
    - Maximum reabsorption occur
    - All the essential nutrients, 70-80% of electrolytes and water, HCO_3^- are reabsorbed.
    - Selective secretion of hydrogen ions, ammonia and potassium ions.
2. **Henle's loop :**
    - Descending limb reabsorb water passively and ascending limb reabsorbed electrolytes actively or passively
3. **DCT :**
    - Conditional reabsorption of Na^+ and water takes place.
    - Reabsorption of HCO_3^- occur.
    - Selective secretion of $K^+$and H^+ ions.
4. **Collecting duct :**
    - Large amount of water and small amount of urea reabsorbed.
    - Selective secretion of H^+ and K^+ ions.

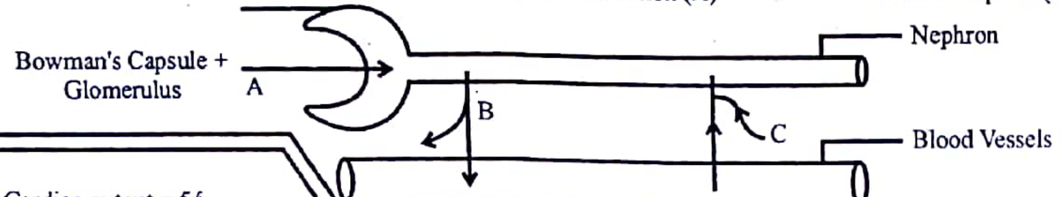
Mechanism of concentration of the Filtrate :

- Mammals have the ability to produce a concentrated urine. The Henle's loop and Vasa recta play a significa role in this.
- Counter current mechanism helps to maintain a concentration gradient in the medullary interstitium. This gradie is mainly caused by NaCl and Urea.
- NaCl is transported by the ascending limb of Henle's loop which is exchanged by the ascending portion of va recta.
- Human kidney can produce urine nearly four times concentrated than the inital filtrate formed.

PHYSIOLOGY OF EXCRETION

is completed in three stages.

1. Ultrafiltration (A)
2. Reabsorption (B)
3. Secretion (C)

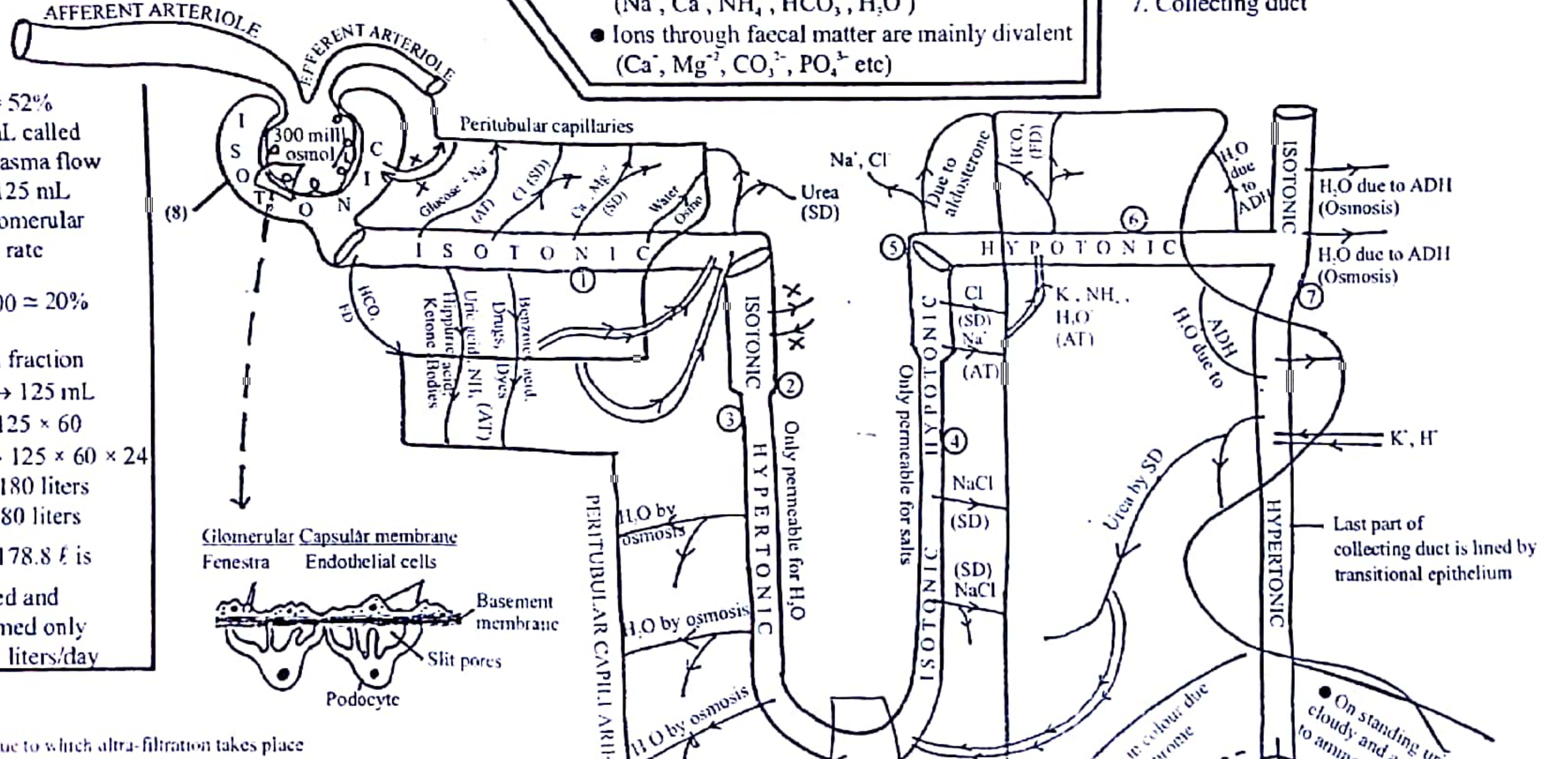

Bowman's Capsule + Glomerulus
A
B
C
Nephron
Blood Vessels

8. Bowman's Capsule
1. Proximal Convoluted Tubule
2. Thick-descending limb of loop of Henle
3. Thin descending limb of loop of Henle
4. Thin ascending limb of loop of Henle
5. Thick ascending limb of loop of Henle
6. Distal Convoluted Tubule
7. Collecting duct

- Cardiac output = 5 ℓ
- Blood to Kidneys = 20 to 25% ≃ 1000 to 1250 mL

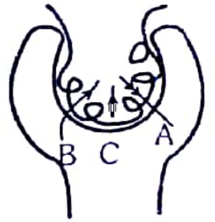
- Ions through urine are mainly monovalent (Na^+, Ca^-, NH_4^+, HCO_3^-, H_3O^+)
- Ions through faecal matter are mainly divalent (Ca^+, Mg^{+2}, CO_3^{2-}, PO_4^{3-} etc)

- Plasma = 52% ≃ 650 mL called Renal plasma flow
- Filter ≃ 125 mL called glomerular filtration rate
- $\frac{125}{650} \times 100 \simeq 20\%$ filtration fraction
- 1 min. → 125 mL
- 1 hr → 125 × 60
- 1 day → 125 × 60 × 24 = 180 liters
- Out of 180 liters 178.2 to 178.8 ℓ is reabsorbed and urine formed only 1.2 to 1.8 liters/day


AFFERENT ARTERIOLE
EFFERENT ARTERIOLE
300 milli osmol
ISOTONIC
(8)
Peritubular capillaries
Glucose + Na+
(AT)
Cl (SD)
Ca, Mg+2
(SD)
Water
Osmo
ISOTONIC
1
HCO3
FD
Hippuric acid, Ketone Bodies
Uric acid, NH3 (AT)
Drugs, Dyes
Benzoic acid.
ISOTONIC
2
3
HYPERTONIC
Only permeable for H2O
Urea (SD)
Na+, Cl-
PERITUBULAR CAPILLARIES
H2O by osmosis
H2O by osmosis
H2O by osmosis
Highly hyperosmotic filtrate
ISOTONIC
HYPOTONIC
Only permeable for salts
4
NaCl (SD)
(SD) NaCl
5
Cl (SD)
Na+ (AT)
K+, NH3, H3O+ (AT)
Due to aldosterone
HCO3 (FD)
HYPOTONIC
6
H2O due to ADH
ISOTONIC
H2O due to ADH (Osmosis)
H2O due to ADH (Osmosis)
7
ADH H2O due to
Urea by SD
K+, H+
HYPERTONIC
Last part of collecting duct is lined by transitional epithelium
Glomerular Capsular membrane
Fenestra
Endothelial cells
Basement membrane
Slit pores
Podocyte
Urine

- Yellow in colour due to urochrome
- On standing urine becomes cloudy and aquires NH_3 odour due to ammonium carbonate
- pH = 6 (Range 4.5 to 8.2)
- Specific gravity (1.015 to 1.02)
- 95% H_2O + 2% electrolytes (Cl^-, SO_4^{2-}, PO_4^{3-}, HCO_3^- of Na, K, (NH_4^+) + 2.6% urea + 0.3% uric acid + traces of NH_3, creatine, creatinine etc

Pressure due to which ultra-filtration takes place



A. Glomerular Hydrostatic Pressure (GHP) - 60 to 75 mm Hg
B. Blood colloidal Osmotic Pressure (BCOP) - 30 to 32 mm Hg
C. Capsular Hydrostatic Pressure (CHP) 10 to 18 mm Hg

Regulation of kidney function :

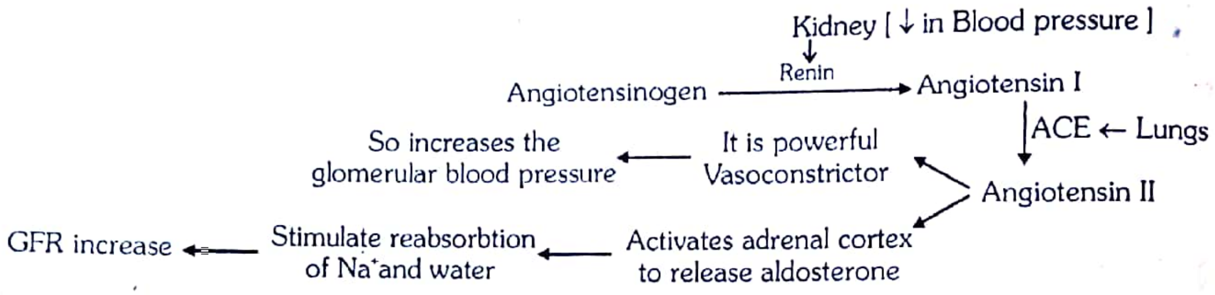
1. **ADH (Anti diuretic hormone)/Vasopressin**

- It is secreted by neurohypophysis.
- It facilitates water reabsorption from later parts of the tubule, thereby preventing diuresis.

Body fluid volume ↑ , ADH secretion ↓,
Water reabsorbtion ↓
Urine volume ↑

2. **Renin - Angiotensin mechanism :**

When glomerular blood pressure or GFR decreases then JG cells of kidney releases **Renin.**


Kidney [↓ in Blood pressure]
Renin
Angiotensinogen
Angiotensin I
ACE ← Lungs
Angiotensin II
It is powerful Vasoconstrictor
So increases the glomerular blood pressure
Activates adrenal cortex to release aldosterone
Stimulate reabsorbtion of Na$^+$and water
GFR increase

3. **ANF (Atrial Natriuretic factor) :**

- An increase in blood flow to the atria of the heart can cause the release of ANF.
- It is vaso dilator so decrease the blood pressure.
- ANF inhibits the Renin angiotensin mechanism.

Micturition :

- The process of release of urine is called micturition and the neural mechanisms causing it, is called the micturition reflex.
- Contraction of smooth mucles of the bladder and relaxation of the urethral sphincter causing micturition.
- An adult human excretes on an average 1-1.5litres of urine per day. Urine is slightly acidic (pH = 6.0). On an average 25-30 gm. urea excreted out per day.
- Other than the kidney, Lungs, Skin and Liver also help in the elimination of excretion wastes.

Lungs → CO_2, Water
Skin → Sweat, Sebum
Liver → Billirubin, Billiverdin, Cholesterol.

LOCOMOTION AND MOVEMENT

- Human endoskeleton is madeup of 206 bones. It is grouped into two parts –
  - → Appendicular skeleton – 126 bones.
  - → Axial Skeleton – 80 bones.

Axial Skeleton

- It consist skull, vertebral column, sternum and ribs.
  - → Skull is composed of cranial and facial bones. Total – 22 bones
  - → Cranial bones are 8 in number. Frontal(1), parietal(2), occipital(1), temporal(2), sphenoid(1), ethmoid(1)
  - → Facial bones are 14 in number. Mandible(1), maxilla(2), palatine(2), nasal(2), vomer(1), inferior turbinals(2) zygomatic(2), lacrimal bones(2).
- Each middle ear contains three tiny bones malleus, incus and stapes, collectively called ear ossicles.
- **Hyoid bone:–** A single U-shaped bone which is present at the base of the buccal cavity.
- **Vertebral column:–** Formed by 26 serially arranged vertebrae. Cervical (7) Thoracic (12) Lumber (5) Sacral (1 fused), coccygeal (1 fused)
- The number of cervical vertebrae are seven in almost all mammals including human beings.
- First vertebra is the atlas and it articulates with the occipital condyles of skull.
  - → **Sternum:–** A flat bone on the midventral line of thorax.

    Ribs – 12 pairs

    – Ist 7 pairs – True ribs (vertebro-sternal ribs)

    – 8, 9, 10th pairs – vertebro-chondral ribs.

    – 11, 12th pairs – vertebral ribs (floating ribs)
- Each rib is a thin flat bone. It has two articulation surfaces on its dorsal end and is hence called bicephalic.
- Thoracic vertebrae, ribs and sternum together form the rib cage.

Appendicular Skeleton

- The bones of limbs along with their girdles.
  - → **Fore Limb –** 30 bones. Humerus, radius, ulna, carpals (wrist bones-8) metacarpals (palm-5) phalanges (digits-14)
  - → **Hind Limb –** 30 bones. Femur, Patella. Tibia, Fibula, Tarsals (Ankle-7), metatarsals (sole-5), Phalanges (digits-14)
- Femur is the longest bone of body.

Pectoral girdle – Each half is made up of a clavical (collar bone) and a scapula bones.

- Glenoid cavity is a depression in the scapula bone in which the head of the humerus bone articulate and form the shoulder joint.

Pelvic girdle – It consists of two coxal bones.

- Each coxal bone is formed by fusion of ilium, ischium and pubis. At the point of fusion of the above bones acetabulum cavity is present in which head of femur articulates. The two halves of the pelvic girdle meet ventrally to form the pubic symphysis containing white fibrous cartilage.

JOINTS

1. **Fibrous joint –** Do not allow any movement e.g.: Sutures (between skull bones)
2. **Cartilaginous Joint –** The bones involved are joined together with the help of cartilage e.g.: Intervertebral disc, pubic symphysis.
3. **Synovial joint –** Characterised by the presence of a fluid filled synovial cavity between the articulating surface of two bones. e.g.: Ball and Socket, Hinge, Pivot, Gliding, Saddle joints.

→ Ball and socket joint (between Humerus and Pectorial girdle)

→ Hinge Joint (Knee Joint, Elbow Joint)

→ Pivot Joint (between atlas and axis)

→ Gliding Joint (between the carpals, between the adjacent vertebrae).

→ Saddle Joint (between carpal and metacarpal of thumb)

Disorders of Skeletal System

Arthritis
(Inflammation of Joints)

Osteoporosis
(Bone mass decreased and bones become weak, porous)

Gout
(Inflammation of Joint due to accumulation of Uric acid Crystals)

HUMAN SKELETON - 206 BONES

APPENDICULAR SKELETON - 126 BONES

LIMB BONES - 120

FORELIMB BONES - 60

HUMERUS - 1X2
RADIUS - 1X2
ULNA - 1X2
CARPALS - 8X2
METACARPALS - 5X2
PHALANGES - 14X2

HINDLIMB BONES - 60

FEMUR - 1X2
PATELLA - 1X2
TIBIA - 1X2
FIBULA - 1X2
TARSALS - 7X2
METATARSALS - 5X2
PHALANGES - 14X2

GIRDLE BONES - 06

PECTORAL GIRDLE - 4

SCAPULA - 1X2
CLAVICLE - 1X2
PELVIC GIRDLE - 2

AXIAL SKELETON - 80 BONES

SKULL SKELETON- 29

SKULL BONES - 22

STERNUM - 01

RIBS - 24

TRUE - 14

VERTEBRAL COLUMN - 26

CERVICAL - 7

CRANIAL - 8

FRONTAL - 1

PARIETAL - 2

TEMPORAL - 2

OCCIPITAL - 1

ETHMOID - 1

SPHENOID -1

FACIAL - 14

MAXILLA - 2

PALATINE -2

MALAR - 2

NASAL - 2

LACRYMAL - 2

INFERIOR TURBINALS -2

MANDIBLE - 1

VOMER - 1

FALSE - 10

THORACIC - 12

LUMBAR - 5

SACRAL - (5)

COCCYGEAL - (4)

ASSOCIATED SKULL BONES - 07

HYOID BONE - 1

EAR OSSICLES - 2X3 (MALLEUS , INCUS , STAPES)

Phalangeal formula is 23333

Bones formed by ossification of tendons are called sesamoid bones.

Longest and strongest bone of human body is femur.

Smallest bone of human body is stapes.

Rabbit - axial skeleton 132 bones , appendicular skeleton 128 bones

MUSCLES

MUSCLES

→ Mesodermal origin

→ 40-50% of body weight

→ Properties - excitability contractility, extensibility and elasticity.

Types of muscles : -

SKELETAL MUSCLES	VISCERAL MUSCLES	CARDIAC MUSCLES
→ Striped muscles	→ Unstriped Muscles	→ Striated muscles
→ Voluntary muscles	→ Involuntary muscles	→ Involantary muscles
→ These muscles are primarily involved in locomotory actions and change in body postures.	→ Located in wall of hollow organs.	→ Found in Heart

- Each muscle bundle madeup of many muscle fibres.
- Skeletal muscle fibre is long, unbranched, multinucleated (syncitium).
- Skeletal muscle fibre contains sarcoplasmic reticulum which is store house of calcium ions.
- Many parallely arranged filaments are present in sarcoplasm called myofilaments or myofibrils.
- Each myofibril has alternate dark and light band on it.
- Light band or I-band or isotropic band contains actin proteins where dark band or A-band or anisotropic band contains myosin proteins.
- Z-Line (elastic fibre) is found in the centre of each 'I' band.
- M Line (thin fibrous membrane) is found in middle of A-band.

> "The portion of the myofibril between two successive 'Z'-Lines is considered as the functional unit of contraction is called Sarcomere."

- In resting stage, the edges of thin filaments partially overlap the free ends of the thick filaments leaving the central part of the thick filaments.
- This central part of thick filament, not overlapped by thin filaments is called the 'H' Zone.

Structure of Contractile Proteins :-

- Each actin is made of two 'f' (filaments) actins which are helically coiled to each other.
- 'f' actin is polymer of 'G' (Globular) actins.
- Two filaments of tropomyosin protein also run close to 'f' actins throughout it's length.
- A complex protein troponin is distributed at regular intervals on the tropomyosin.
- In the resting state troponin masks the active binding sites for myosin on the actin filaments.
- Each myosin filament is a polymerized protein. Many meromyosin (monomeric protein) found in one thick filament.

Meromyosin
- → **1. HMM (Heavy meromyosin) :** A globular head with a short arm.
- → **2. LMM (Light meromyosin) :** It includes tail.

NOTE: ATPase enzyme and binding site for ATP and actin present on globular head.

Mechanism of muscle contraction :-

- It is best explained by sliding filaments theory.
- During this, thin filaments slide over the thick filaments.
- Muscle contraction is initiated by a signal sent by the central nervous system.
- A neural signal reacting at neuromuscular junction or motor end plate (junction between motor neuron and sarcolemma) releases a neuro-transmitter (Acetylcholine) which generates an action potential in sarcolemma.

- Action potential spreads through the sarcolemma and causes release of Ca^{+2} into sarcoplasm.
- When Ca^{+2} level increase it leads to binding of Ca^{+2} with subunit of troponin on actin filament remove maskin of active sites on actin to form a cross-bridge. (Energy obtained from ATP hydrolysis).
- Actin filaments move torwards centre of A-band.
- Length of sarcomere decreases.
- I-band get reduced where as 'A' band retain the length.
- The myosin releasing ADP and P goes back to its relaxed stage.

Muscle Fatigue : -

- Repeated activation of muscle can lead to accumulation of lactic acid due to anaerobic breakdown of glycogen causing fatigue.

Types of muscles fibres : –

Red Muscle Fibre	White Muscle Fibre
• Myoglobin content is high (myoglobin is red coloured oxygen storing pigment).	• Myoglobin content is Low.
• More number of mitochondria present.	• Less number of mitochondria present.
• Aerobic muscle fibres.	• Anaerobic muscle fibres.
• Amount of sarcoplasmic reticulum is low.	• Amount of sarcoplasmic reticulum is high.

NEURAL CONTROL AND CO-ORDINATION

Co-ordination : It's the process through which two or more organs interact and complement the functions of one another.

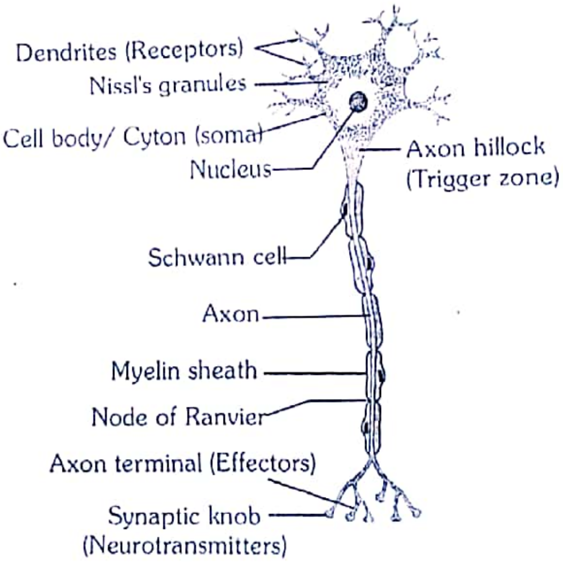
Integrated system : In Human's body the neural system and the endocrine system jointly coordinate and integrate all the activities of the organs so that they function in a synchronised fashion and interdependent to each other combinely called integrated system.

Distinction in neural system and endocrine systems.

The neural system provides an organised network of **point to point** connections for a quick response (Fast speed) and short span of coordination where as the endocrine system provides chemical integration, slow speed and long lasting effect.

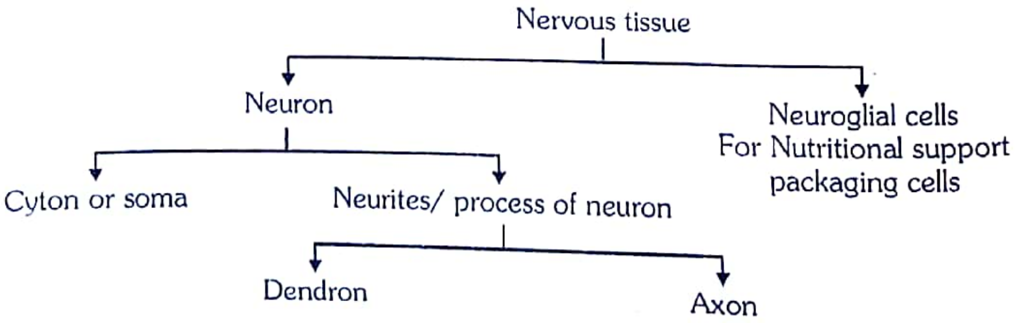
Neural system :

Neurons : The neural system of all animals is composed of highly specialised cells called neurons also known as structural and functional unit of nervous system.



Dendrites (Receptors)
Nissl's granules
Cell body/ Cyton (soma)
Nucleus
Axon hillock
(Trigger zone)
Schwann cell
Axon
Myelin sheath
Node of Ranvier
Axon terminal (Effectors)
Synaptic knob
(Neurotransmitters)

Structure of a neuron (Multipolar)



Nervous tissue
Neuron
Neuroglial cells
For Nutritional support
packaging cells
Cyton or soma
Neurites/ process of neuron
Dendron
Axon

- Three major parts of neuron, are dendron, cyton and axon.

Nissl's granules : The cell body contains cytoplasm with typical cell organelles and certain granular bodies called Nissl's granules which is also present in dendrites.

Types of Neuron
(Based on number of axon and dendrites)

Multipolar
Cell body with two or more short dendrites and one long axon
Ex. Cerebral cortex

Bipolar
Cell body with one axon and one dendrite
Ex. Retina, Schneidarian epithelium (olfactory epithelium)
Gustatory epithelium (Tongue)
Membranous labyrinth (Internal ear)

Unipolar
cell body with one axon only
Ex. Embryonic stage (Foetus)

Types of axon
(On the basis of Myelin)

Myelinated Nerve Fibres
Enveloped by Schwann cells which form myelin sheath
The gaps between two adjacent myelin sheath are called **Nodes of Ranvier**
Ex. Cranial nerves and **Spinal nerves**

Unmyelinated Nerve Fibres
It's enclosed by a Schwann cell that does not form a myelin sheath around the axon and is commonly found in **Autonomous** and the **Somatic neural system**

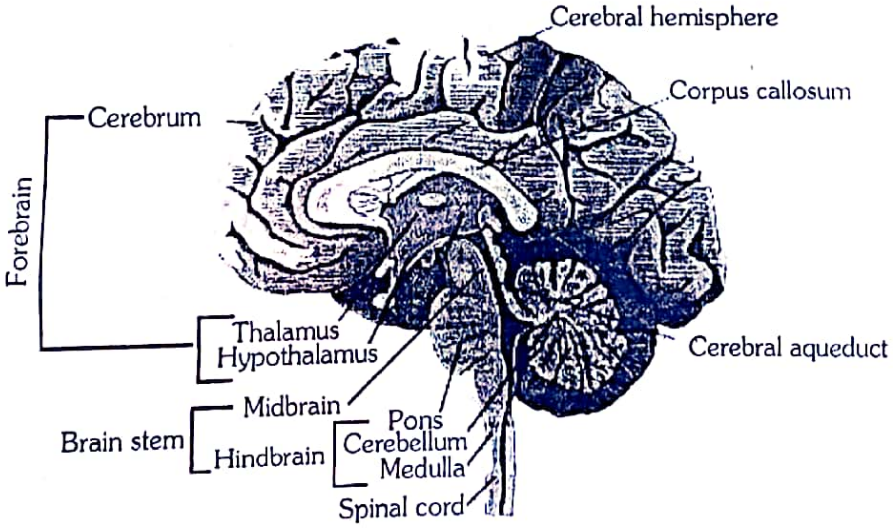
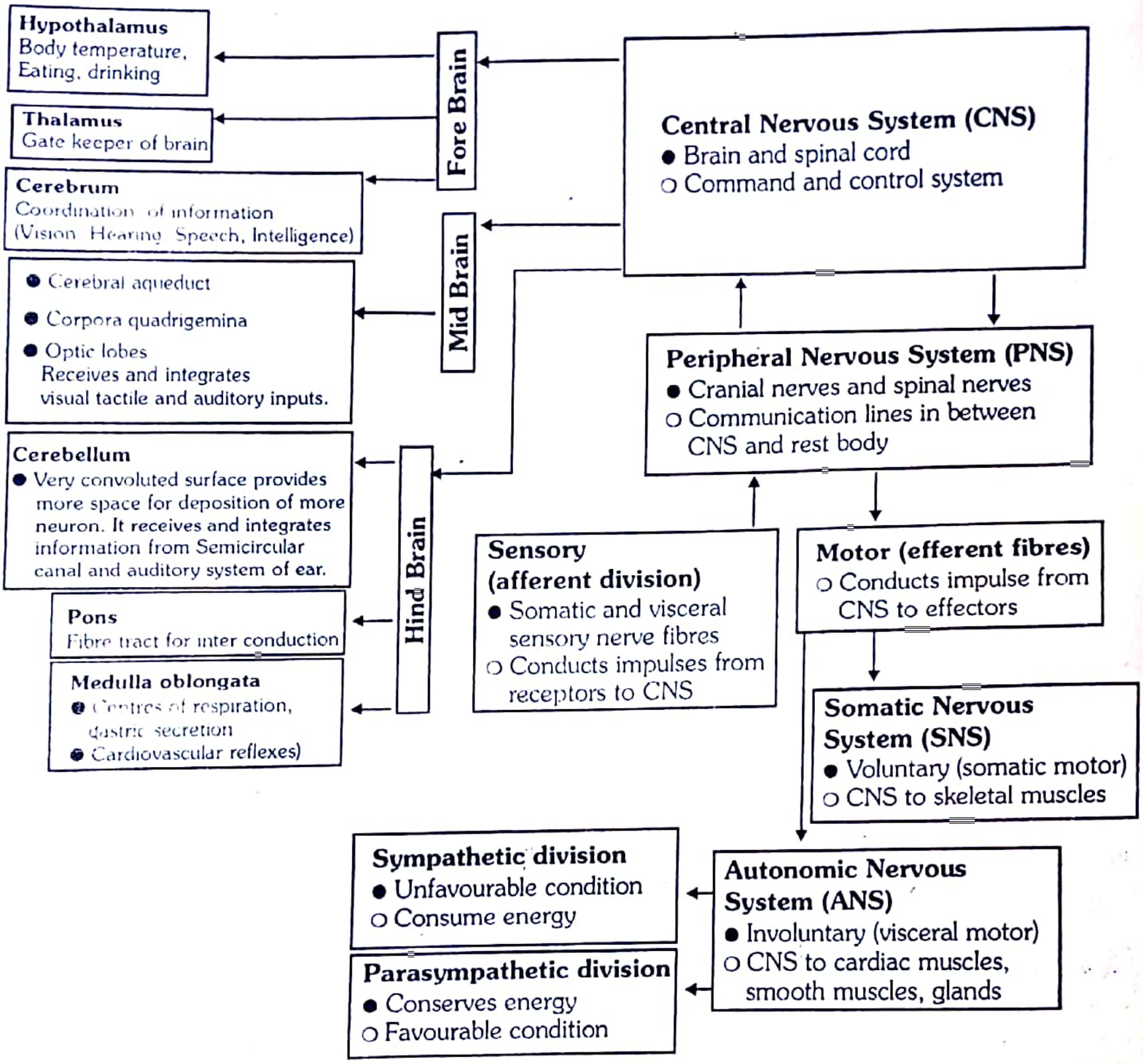

Cerebral hemisphere
Corpus callosum
Cerebrum
Forebrain
Thalamus
Hypothalamus
Cerebral aqueduct
Midbrain
Brain stem
Hindbrain
Pons
Cerebellum
Medulla
Spinal cord

Diagram showing sagital section of the human brain

Human Neural System (Memory map)


Hypothalamus
Body temperature, Eating, drinking
Thalamus
Gate keeper of brain
Cerebrum
Coordination of information (Vision, Hearing, Speech, Intelligence)
Fore Brain
Central Nervous System (CNS)
● Brain and spinal cord
○ Command and control system
Mid Brain
● Cerebral aqueduct
● Corpora quadrigemina
● Optic lobes
Receives and integrates visual tactile and auditory inputs.
Peripheral Nervous System (PNS)
● Cranial nerves and spinal nerves
○ Communication lines in between CNS and rest body
Cerebellum
● Very convoluted surface provides more space for deposition of more neuron. It receives and integrates information from Semicircular canal and auditory system of ear.
Hind Brain
Pons
Fibre tract for inter conduction
Medulla oblongata
● Centres of respiration, gastric secretion
● Cardiovascular reflexes)
Sensory (afferent division)
● Somatic and visceral sensory nerve fibres
○ Conducts impulses from receptors to CNS
Motor (efferent fibres)
○ Conducts impulse from CNS to effectors
Somatic Nervous System (SNS)
● Voluntary (somatic motor)
○ CNS to skeletal muscles
Sympathetic division
● Unfavourable condition
○ Consume energy
Parasympathetic division
● Conserves energy
○ Favourable condition
Autonomic Nervous System (ANS)
● Involuntary (visceral motor)
○ CNS to cardiac muscles, smooth muscles, glands

Limbic system

It is a complex structure which includes inner parts of cerebral hemisphere and associated deep structures like amygdala, hippocampus. Along with hypothalamus, it is involved in olfaction autonomous response, regulation of sexual behaviour, expression of emotional reaction (Excitement, pleasure, rage and fear) and motivation.

Cranial meninges : Inside skull the brain is covered by cranial meninges, consisting of outer duramater, middle arachnoid, and inner piamater.

Cerebral hemispheres : A deep cleft divides the cerebrum longitudinally into two halves, termed as the left and right cerebral hemisphere.

Corpus callosum : The cerebral hemispheres are connected by a tract of nerve fibres called corpus callosum.

Cerebral cortex : The layer of cells which covers the cerebral hemisphere is called cerebral cortex, thrown in to prominent folds.

Gray matter : The cerebral certex is referred as the gray matter due to grayish appearance and it is due to highly concentrated neuron cell bodies.

White matter : Fibres of the tract are covered with myelin sheath which constitute the inner part of cerebral hemispheres and gives the opaque white appearance to the layer hence called the white matter.

Association area : The cerebral cortex contains motor area, sensory area and large regions called association areas responsible for complex functions like intersensory association, memory and communication.

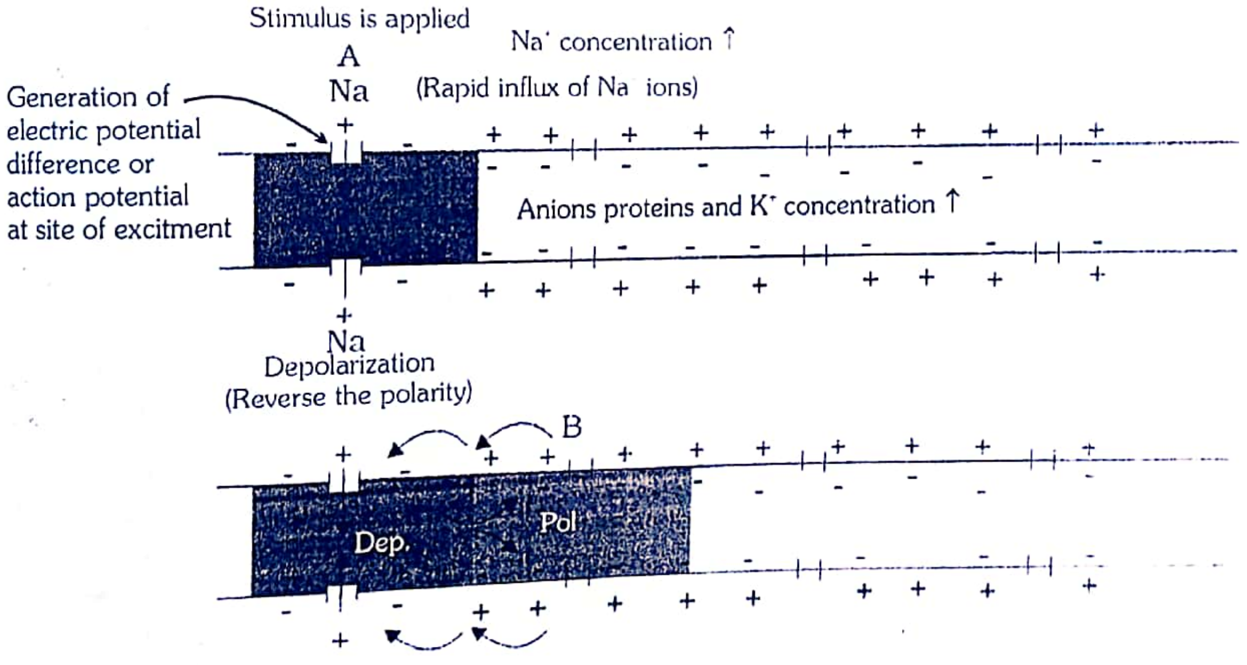
The neural system coordinate and integrates function as well as metabolic and homeostatic activities of all the organs.

Generation and conduction of nerve impulse

Excitable cells : Neurons are excitable cells because their membranes are in a polarized state due to differential concentration gradient of ions across the membrane. Different types of ion channels are present on neuronal membrane for which this membrane is selectively permeable.

Resting stage : When neuron is not conducting any impulse in that stage axonal membrane is more permeable for K^+ ions and nearly impermeable for Na^+ ions .Ionic gradient across the resting membrane is maintained by active transport of ions by **Na^+-K^+ pump.**

Polarized stage : By the presence of high concentration of Na^+ in fluid out side of axon, K^+ ions & negativety charged proteins in axoplasm and due to Na^+ – K^+ pump axonal membrane possesses a positive charge on outer surface and negative charge on its inner surface therefore its called **polarized.**


Stimulus is applied
A
Na
Na⁺ concentration ↑
(Rapid influx of Na⁺ ions)
Generation of electric potential difference or action potential at site of excitment
Anions proteins and K⁺ concentration ↑
Na
Depolarization
(Reverse the polarity)
B
Dep.
Pol

Diagrammatic reprsentation of impulse conduction thourgh an axon
Inner surface current flow A to B and outer surface from B to A

Resting potential : The electric potential difference across the resting plasma membrane is called as the resting potential.

Nerve impulse : Nerve impulse is conducted along the axon membrane in the form of depolarization and repolarization.

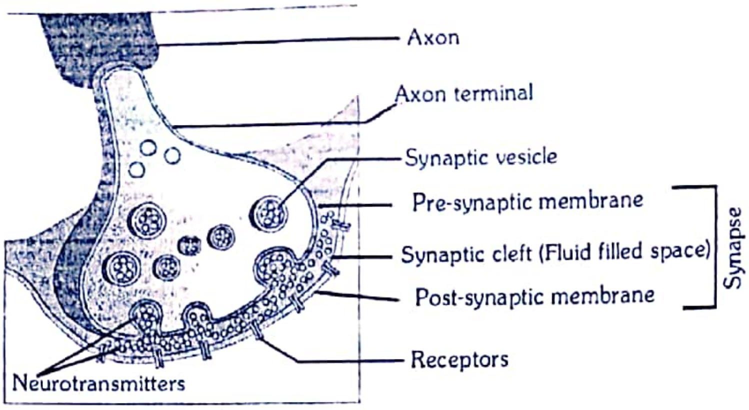

Axon
Axon terminal
Synaptic vesicle
Pre-synaptic membrane
Synaptic cleft (Fluid filled space)
Post-synaptic membrane
Synapse
Receptors
Neurotransmitters

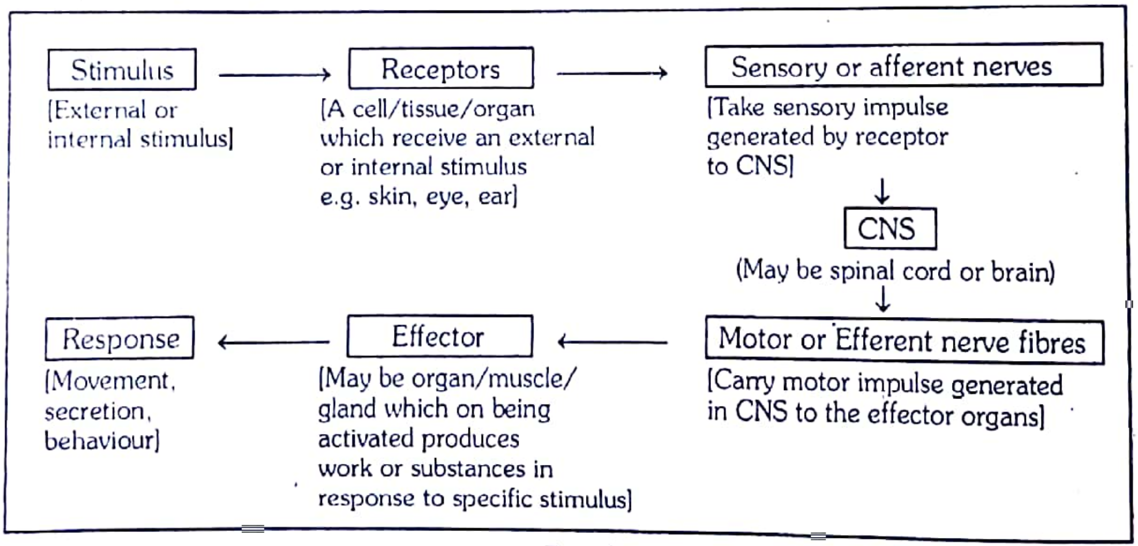
Diagram showing axon terminal and synapse

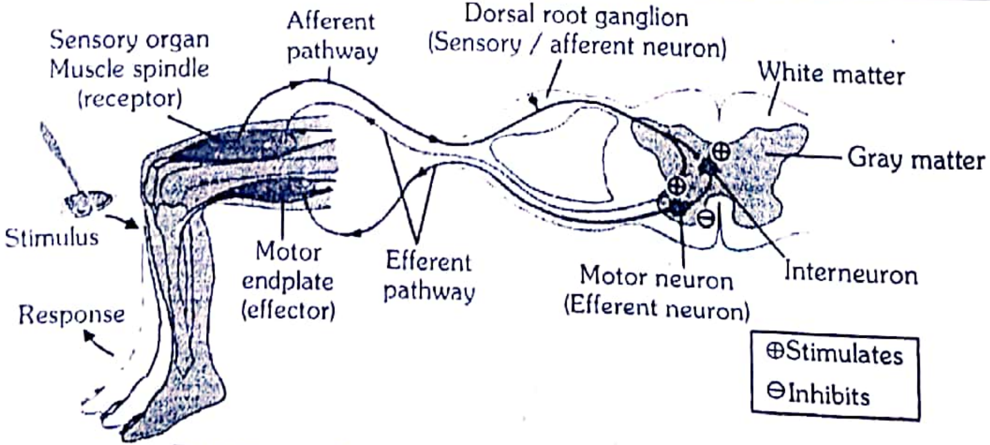
Types and difference in synapses : Two types of synapses are present namely electrical synapses and chemical synapses.

At electrical synapses the membranes of pre and post synaptic neurons are in very close proximity. Electric current flow directly from one neuron to other which is very similar to impulse conduction along a single axon. Impulse transmission across an electrical synapse is always faster than across a chemical synapse.

In chemical synapses when an impulse (action potential) arrives at the axon terminal, it stimulates the movement of the synaptic vesicles towards the membrane where they fuse with plasma membrane and release their neurotransmitter in the synaptic cleft. The released neurotransmitter binds to their specific receptors present on post synaptic membrane this binding opens ion channels allowing the entry of ions which can generate new potential may be either excitatory or inhibitory.

Reflex action and reflex arc : Sudden withdrawl of a body part which comes in contact with hot, cold, pointed object this entire process is involuntary response to a peripheral nervous stimulation called reflex action. The reflex pathway comprises at least one afferent and efferent neuron appropriately arranged in series.


Stimulus
[External or internal stimulus]
Receptors
[A cell/tissue/organ which receive an external or internal stimulus e.g. skin, eye, ear]
Sensory or afferent nerves
[Take sensory impulse generated by receptor to CNS]
CNS
(May be spinal cord or brain)
Motor or Efferent nerve fibres
[Carry motor impulse generated in CNS to the effector organs]
Effector
[May be organ/muscle/ gland which on being activated produces work or substances in response to specific stimulus]
Response
[Movement, secretion, behaviour]


Sensory organ
Muscle spindle
(receptor)
Afferent pathway
Dorsal root ganglion
(Sensory / afferent neuron)
White matter
Gray matter
Stimulus
Response
Motor endplate
(effector)
Efferent pathway
Motor neuron
(Efferent neuron)
Interneuron
⊕Stimulates
⊖Inhibits

Diagrammatic presentation of reflex action
(showing knee jerk reflex)

SENSORY ORGAN

Sensory receptor and processing :

The sensory organs detect all types of changes in the enviroment and send appropriate signals to the C.N.S. where all the inputs are processed and analysed. Signals are then sent to different parts / centres of the brain. thus you can sense changes in the environment.

EYE

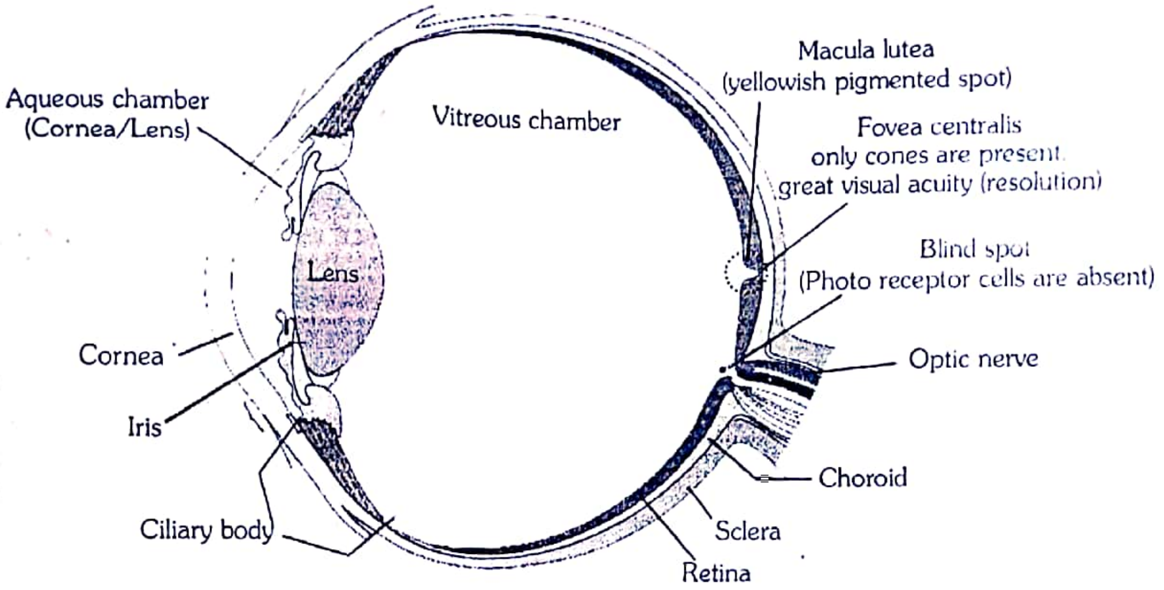

Aqueous chamber
(Cornea/Lens)
Vitreous chamber
Macula lutea
(yellowish pigmented spot)
Fovea centralis
only cones are present
great visual acuity (resolution)
Blind spot
(Photo receptor cells are absent)
Lens
Cornea
Iris
Optic nerve
Choroid
Ciliary body
Sclera
Retina

Diagram showing part of an eye

Parts of eye

Sclera
- External layer (Collagen)
- Dense connective tissue
- Anterior portion-cornea

Choroid
- Middle layer
- Dense vascular layer
- Looks bluish

Ciliary body
present at anterior part

Iris
- Pigmented and Opaque structure
- Visible coloured portion of eye.
- Located In front of lens
- A aperture is surrounded by Iris called pupil

Retina
- Inner layer
- Three layered
- Inside to outside

Ganglionic cells
(Inside)

Bipolar cells

Photoreceptor cells
(outside)

Rods
Twilight or scotopic vision
Rhodopsin photopigment
(Purplish - red protein visual purple)
It's derivative of Vit-A.

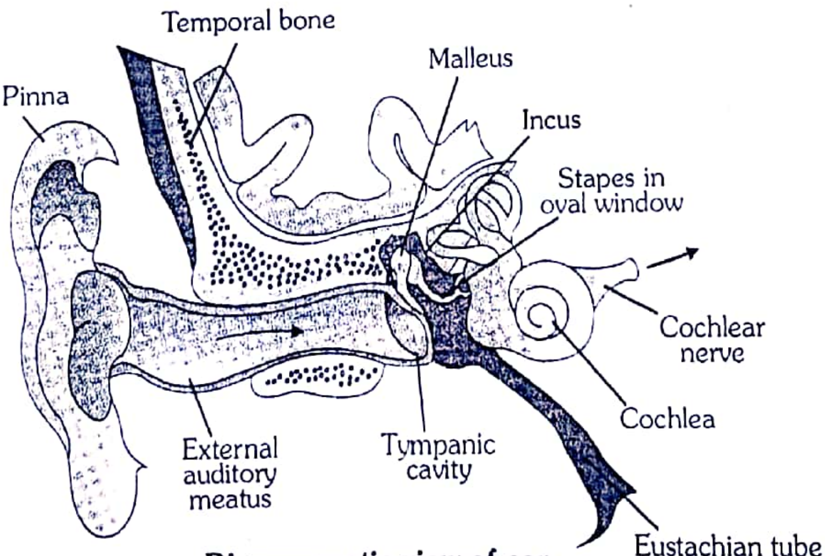
Cones
Day light vision
(Photopic vision)
Colour vision
Defferent types of cones
photopigments respond to
red, blue & green

Light rays in visible wave length focus on
↓
Cornea
↓
Lens
↓
Retina

- Rods (Rhodopsin)
  Light induces dissociation (Bleaching)
  - Opsin (Protein)
  - Retinal (Vitamin-A)
    Causes membrane permeability
    Creates potential difference
- Cones (Iodopsin)
  (Colour differentiation)

↓
Bipolar cells
↓
Ganglionic cells (Action potential)
↓
Optic nerve
↓
Visual cortex of brain
(Analysis and formation of image based on earlier memory and experience)

THE EAR Perform two sensory functions hearing and maintenance of body balance.



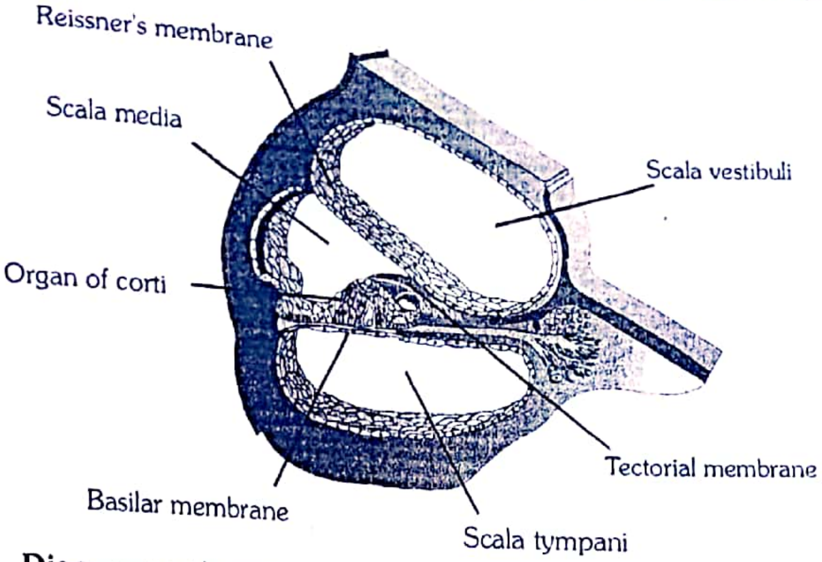
Temporal bone
Pinna
Malleus
Incus
Stapes in oval window
Cochlear nerve
Cochlea
External auditory meatus
Tympanic cavity
Eustachian tube

Diagrammatic view of ear

Ear
↓

- Outer Ear
  - Pinna
  - External auditory meatus
- Middle Ear
  - Malleus
    ↓
    Attached to tympanic membrane
  - Incus
  - Stapes
    ↓
    Attached to oval window and opens in cochlea
- Inner Ear
  (Fluid filled called labyrinth)
  - Bony labyrinth
    ↓
    Perilymph
  - Membranous labyrinth
    ↓
    Endolymph

- An eustachian tube connects the middle ear cavity with the pharynx and helps in equalising pressure on either side of eardrum



Diagrammatic representation of the sectional view of cochlea

Internal Ear ↓

- Cochlea ↓
  - Scala vestibuli (Dorsal) ······ Reissner's membrane ······ Scala media (Middle) ······ Basilar membrane ······ Scala tympani (ventral)
  - Scala vestibuli — Opens ↓ Oval window
  - Basilar membrane ↓ Organ of corti which *contains hair cells as auditory receptors* ↓
    - Apical part having large number of processes stereocilia above it thin elastic membrane tectorial membrane
    - Basal part in close contact with afferent nerve fibres
  - Scala tympani — Opens ↓ Round window ↓ Middle ear
- Vestibular apparatus (Located above cochlea) ↓
  - 3-semi circular canals (at right angles) ↓ Swollen base ↓ **Ampulla** Projecting ridges **Crista** ampullaris
  - Otolith organs ↓
    - Saccule
    - Utricle
    - Projecting ridges macula
  - Crista ampullaris and macula ↓ Specific receptors of vestibular apparatus maintains body balance and posture.

Mechanism of hearing

Sound Waves (20-20,000 Hz) → External ear → Eardrum ↓ Malleus incus stapes (Ear ossicles) → Oval window → Cochlea → Basilar membrane ↓ Bend the hair cells pressing them against tectorial membrane → Afferent fibres via auditory nerves ↑ auditory cortex area where sound analysed and recognised

CHEMICAL COORDINATION AND INTEGRATION

INTEGRATIVE SYSTEMS

- Neural system and endocrine system jointly co-ordinate and regulate the physiological functions of the body.
- **Note:** Nervous system provides rapid co-ordination where endocrine system provides slow co-ordination with different body parts.
- **Hormone :-** Secretion of endocrine glands (Ductless glands) called as hormones. "Hormones are non-nutrient chemicals which act as intercellular messenger and are produced in trace amounts."

Note: Intercellular messenger = Passes message from one cell to another cell by binding with membrane bound receptors or receptors located inside the cell.

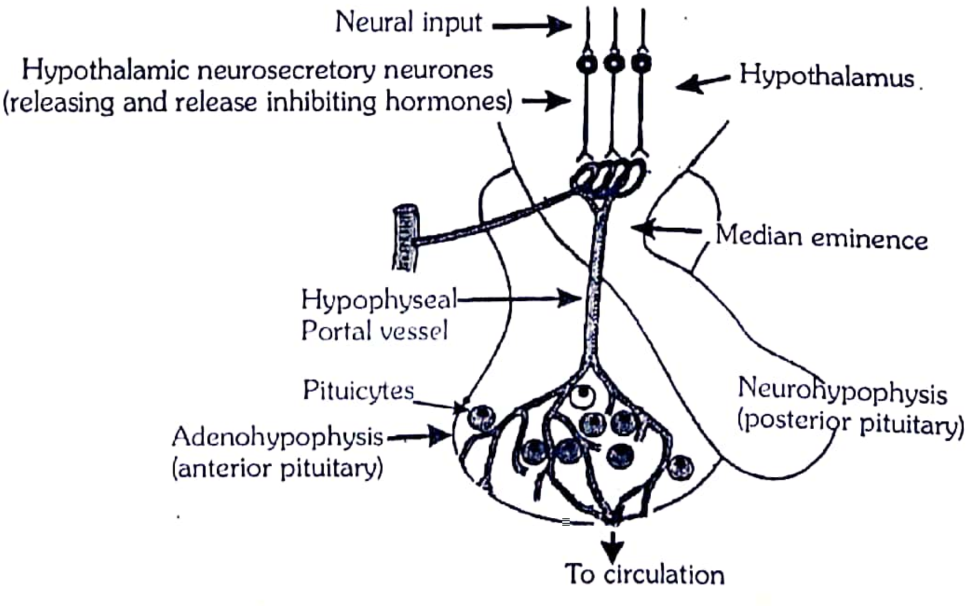
- **Receptors :-** Protein molecules specific for particular hormone molecules.

  Position of Receptors - Located on cell surface or intracellular.
- **Organised endocrine Glands (Whole gland) :** Pituitary gland, Pineal gland, Thryoid gland, Adrenal Gland, Pancrease, Parathyroid gland, Thymus and Gonads.
- **Other unorganised endocrine tissue (Diffused tissue) :** GIT, Kidney, Heart etc.

HYPOTHALAMUS

- Basal part (ventral part) of Diencephalon.
- Group of neurosecretory cells known as nuclei (Nuclei = group of cyton in CNS) secrete 7 releasing hormones (which stimulate secretion) and 3 inhibiting (which inhibit secretion) hormones. These hormone regulate the synthesis and secretion of pituitary hormones.
- Hypothalamo hypophyseal portal system regulate functions of anterior pituitary.
- In this portal system releasing and inhibiting hormones are transfer to anterior pituitary by hypophyseal portal vein and stimulate hormone synthesis & secretion of anterior pituitary.
- Posterior pituitary is under the direct regulation of the hypothalamus.
- Hormones of posterior pituitary are synthesised into hypothalamic nuclei **(Paraventricular nuclei and supra optic nuclei)** and secreted into posterior pituitary through axons. So these are stores and again release into body via blood stream.

PITUITARY GLAND


Neural input
Hypothalamic neurosecretory neurones
(releasing and release inhibiting hormones)
Hypothalamus
Median eminence
Hypophyseal
Portal vessel
Pituicytes
Adenohypophysis
(anterior pituitary)
Neurohypophysis
(posterior pituitary)
To circulation

Pituitary gland
(anatomical division)

- Adenohypophysis
  - Pars distalis (anterior pituitary)
    - (A) Somatotrophs ⇒ secrete GH/STH
      - Stimulates growth of bone, cartilage and soft tissues (Muscles & liver).
      - Stimulates metabolism of proteins fat and carbohydrates.
    - (B) Lactotrophs ⇒ secrete PRL/LTH
      - Regulates growth of mammary glands and formation of milk in them
      - Responsible for lactation after delivary
      - Hormone of maternity
    - (C) Corticotrophs ⇒ secrete ACTH
      - Stimulates the synthesis and secretion of steroid hormones from adrenal cortex. (glucocorticoids & steriod hormones)
    - (D) Thyrotrophs ⇒ secrete TSH
      - Stimulates thyroid gland for synthesis and secretion of thyroid hormone (thyroxine)
    - (E) Gonadotrophs ⇒ secrete LH & FSH stimulates gonadial activity and hens called gonadotropins
      - FSH ⇒ In male, FSH and Androgen (secreted from testes) both regulates spermatogenesis and normal functioning of seminiferous tubules.

        In female, FSH stimulates growth and development of ovarian follicles
      - LH ⇒ In males, LH stimulates the synthesis and secretion of hormones called Androgens from testes.

        In females, LH induces ovulation of fully mature follicles (graffian follicles) and maintains the corpus luteum.
  - Pars intermedia (middle pituitary)
    - Melanocyte Stimulating Hormone (MSH)
- Neurohypophysis
  - Infundibulum
  - Pars nervosa (Posterior pituitary)
    - **Oxytocin** or Pitocin or **Birth hormone**
      - Stimulates uterine contraction during the time of child birth .
      - Stimulates milk ejection from the mammary gland.
      - Helps in egg laying in birds
      - Artificial injected in cattles (cow and buffaloes) for instant milk ejection.
    - ADH or Vasopressin or Pitressin
      - Mainly acts on kidney and stimulates reabsorption of water by distal tubules and there by reduces loss of H_2O through urine (Diuresis) so called as **antidiuretic hormone.**

Pituitary hormone disorder

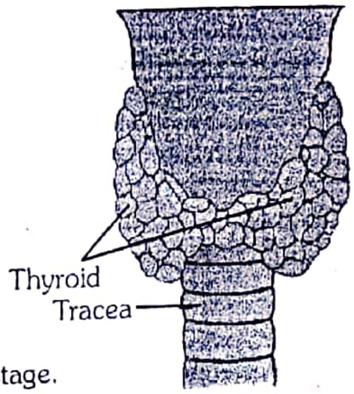
- Hyposecretion
  - (1) Childhood - Dwarfism (STH)
  - (2) Diabetes insipidus (ADH)
- Hypersecretion
  - (1) Childhood - Gigantism (STH)
  - (2) Adulthood - Acromegaly (STH)

PINEAL GLAND (Dorsal side of forebrain)

- Hormone = Melatonin
- Melatonin regulate 24 hours diurnal rhythms of body.
- Melatonin maintain rhythms of body like - sleep wake cycle, body temperature.
- Melatonine also influence metabolism, pigmentation, menstrual cycle and defense capability.
- After 7 year of birth pineal gland undergo involution and crystal of $CaCO_3$ and $Ca_3.PO_4$ are deposited in it called "**Brain sand**".

Note: Melatonin provide light colour to skin. It play role in metachrosis (change in colour) of amphibia.

THYROID GLAND



Ventral view of thyroid gland

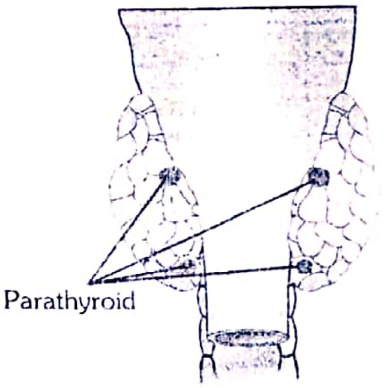
- Largest endocrine gland of body.
- Located at both side of trachea (or at Junction of trachea and larynx)
- Bilobed gland (Lobes are interconnected by a thin flap of connective tissue called Isthumus)
- Each lobe composed of follicles and stromal tissue.
- Follicular cells of follicle synthesize T_3 & T_4 (thyroxine) hormones.
- Thyroid is only gland in the body which stores its hormone in inactive stage.
- **Function of Thyroid Hormone –**
  - → Regulation of basic metabolic rate.
  - → Support the process of RBC formation.
  - → Control the metabolism of Carbohydrate, proteins & fats.
  - → Maintenance of water and electrolyte balance.

Thyroid hormone disorder

- Hyposecretion
  - **Childhood**
    Cretinism :-
    In pregnancy defective development and maturation of growing baby
    Children are called cretin.
    Mentaly retard, low intelligence quotient, abnormal skin. deaf-mutism
  - **Adulthood**
    (1) Myxoedema : (Gull's disease)
    falling of hair, loose and swollen skin, deposition of adipose fat.
    (2) Simple goitre/Endemic goitre
    (3) Hashimoto's disease/suicide of thyroid/Autoimmune thyroiditis.
- Hypersecretion
  - (1) Exophthalmic Goitre / Grave's disease / Basedow's disease
    Protrusion of eye balls, increased BMR and weight loss
  - (2) Plummer's disease/Toxic adenoma

- **Thyrocalcitonin** (TCT) regulate blood Ca^{+2} level (↓ Ca^{+2} level in blood) by excretion of Ca^{+2} in urine and enhance deposition of Ca^{+2} in bones.

PARATHYROID GLAND



Dorsal view

- Four parathyroid glands are present on back side of thyroid gland.
- Hormone = peptide hormone – PTH (Parathyroid Hormone).
- Also called as **Collip's** hormone.
- **Function of hormone –**

→ PTH increases the Ca^{+2} levels in blood.

→ PTH acts on bones and stimulates the process of bone reabsorption (dissolution/demineralisation).

→ PTH also increase reabsorption of Ca^{+2} from renal tubules and from digested food.

→ PTH & TCT play significant role in Ca^{+2} balance in the body (Antagonistic Hormones).

→ Required for proper functioning of muscular activities, nerve impulse conduction, heart beat, blood coagulation, bone formation and fertilization of ova.

Parathyroid hormone disorder

Hyposecretion

(1) *Hypocalcaemia*
(Decreased amount of Ca^{+2} in ECF)
Hyperphosphatemia (PO_4^{-3} increased)
(2) Tetany convulsion and cramping (in Voluntary muscle) Asphyxia leads to death (in Involuntary muscle like diaphragm)

Hypersecretion

(1) Hypercalcaemia
(Increased amount of Ca^{+2} in ECF)
and **Hypophosphatemia** (PO_4^{-3} decreased)
(2) **Osteoporosis** due to activation of osteoclast cells in bone.

THYMUS GLAND

- Lobular structure located on dorsal side of the heart and the aorta.
- Secretion = peptide hormone – Thymosin.
- Function of hormone –

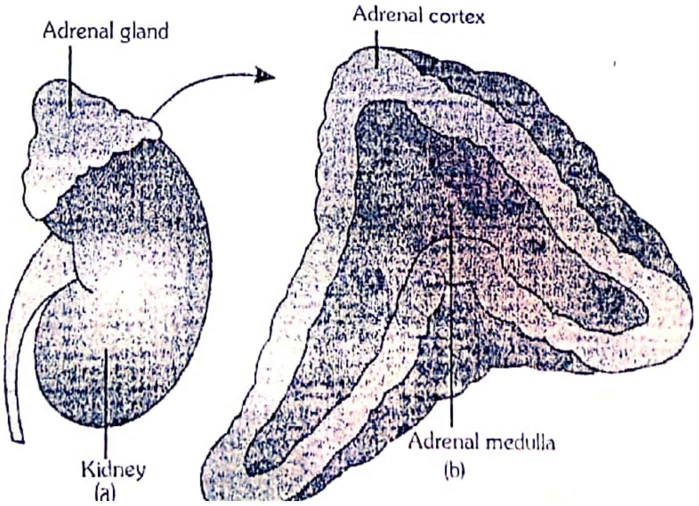
→ Play major role in development of immune system.

→ Play major role in the differentiation of T lymphocytes. (T-lymphocytes provide cell mediated immunity) thats why also called "**Throne of immunity**" or "**Training school of T-lymphocytes**".

→ Also promote production of antibodies to provide humoral immunity.

- Thymus is degenerated in old individuals resulting in a decreased production of thymosin by which immune responses of old person become **weak**.
- Hyper secretion of thymosin may be associated with ***myasthenia gravis***.

ADRENAL GLAND



Adrenal Gland

Consists of two regions

- Cortex (outer) (80 - 90%)
  - Mesodermal in origin
  - Subdivided into three zones
    - Zona glomerulosa
      - Secretes mineralocorticoids
      - **Aldosterone**
        (1) Acts on renal tubules & helps in reabsorption of Na^+ & Cl^- ions and ***controls the excretion of K^+ ions***
        (2) Also known ***as salt retaining*** hormone
        (3) Maintain osmotic pressure and blood pressure.
    - Zona fasciculata
      - Secretes glucocorticoids
      - **Cortisol**
        (1) Increase gluconeogenesis, lipolysis and proteolysis.
        (2) Anti inflammatory hormone and suppress immune system.
        (3) Stimulate RBC production.
        (4) Maintain cardio - vascular system and kidney functions.
    - Zona reticulata
      - Secretes sexcorticoids
      - **Androgens & Oestrogens**
        (1) Promote growth of axial hair, pubic hair and facial hair during puberty.
        (2) Promote secondary sexual characters.
- Medulla (inner) (10 - 20%)
  - Ectodermal in origin
  - Consist of chromaffin cells
  - Secretes two hormones commonly called as **catechalomines** or **Emergeny hormones** or hormones of **flight** and **fight.**
    - Adrenaline
    - Noradrenaline
  - ↑ Pupilary dilation
  - ↑ Heart beat
  - ↑ B.P.
  - ↑ Alertness
  - ↑ Piloerection
  - ↑ Stimulates break down of glycogen in glucose
  - ↑ Stimulates break down of lipids & proteins
  - ↓ Salivation
  - ↓ Peristalsis of alimentary canal etc.

Adrenal gland is called 'triple F gland' (FFF gland). It is also called 4S (Stress, sugar, metabolism, salt retention and sex corticoids).

Adrenal hormone disorder

- Hyposecretion
  (1) Addison's disease (Hypoadrenalism)
  Dehydration in the body, Blood pressure, BMR and body temperature are reduced, excretion of water and Na increase.
- Hypersecretion
  (1) Cushing's syndrome
  Excess deposition of fat under skin.
  Moon face, fish mouth, buffalo hump.
  Protein catabolism ↑ , Hyperglycemia.
  (2) Sex steroids
  (i) Adrenal virilism

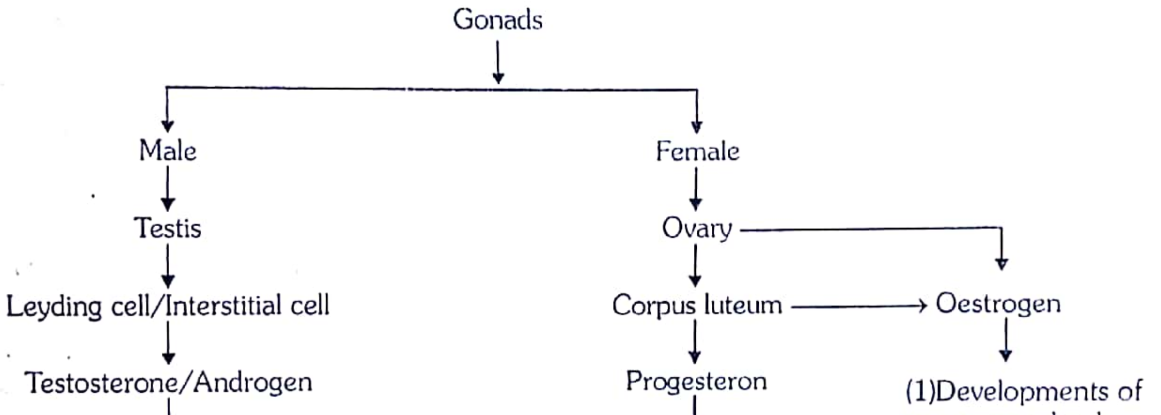
PANCREAS

- Composite gland which acts as both exocrine (pancreatic acini) and endocrine (islets of langerhans).
- The two main types of cells α and β cells found is islets of langerhans secrete glucogon and insulin hormone respectively.

GLUCAGON	INSULIN
It is a peptide hormone	It is also a peptide hormone
Glucagon acts mainly on hepatocytes and stimulates glycogenolysis resulting in an increased blood glucose (Hyperglycemia) level.	Insulin acts mainly on hepatocytes and adipocytes and enhances cellular glucose uptake and utilisation. Decrease blood glucose level = Hypoglycemia
Glucagon stimulates the process of gluconeogenesis.	Insulin stimulates glycogenesis.

- **Note:** Prolonged hyperglycemia leads to a complex disorder called **Diabetes mellitus.** (loss of glucose through urine and formation of ketone bodies). Treatment - **Insulin therapy**.

HORMONE OF GONADS, HEART, KIDNEY AND GASTROINTESTINAL TRACT.



(1) Stimulate spermatogenesis.
(2) development, maturation and functions of accessory of male sex organs.
(3) Stimulate muscles growth, growth of facial and axillary hair, aggressiveness, low pitch voice.
(4) Influence the male sexual behaviour **(libido)**.
(5) Anabolic effect on protein & carbohydrate metabolism.

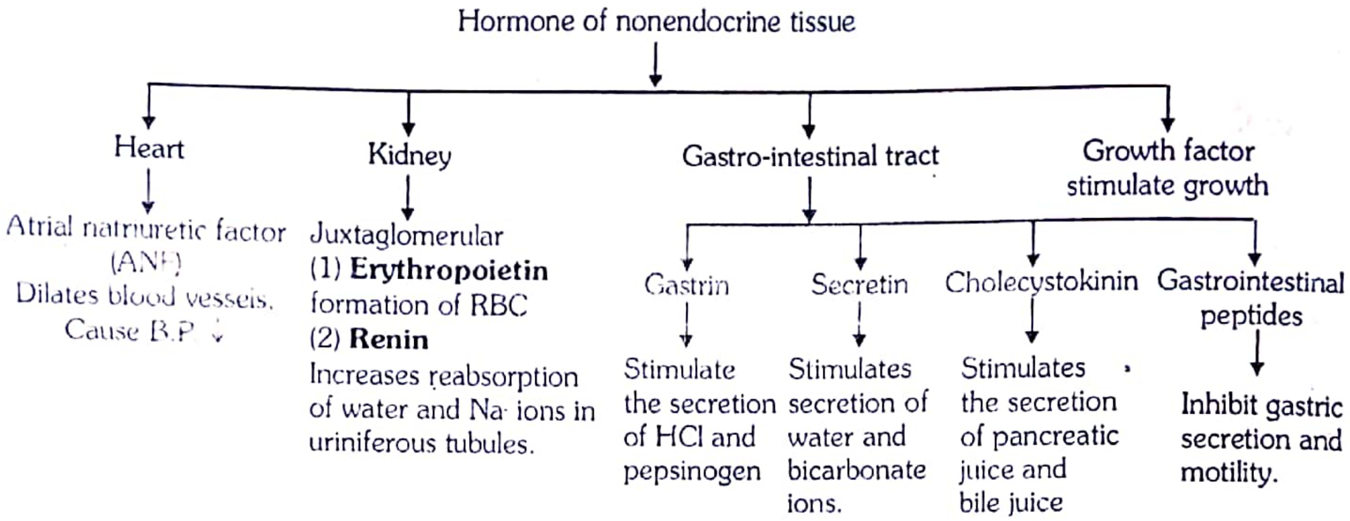
(1) Supports pregnancy.
(2) acts on the mammary glands and stimulates the formation of alveoli.

(1)Developments of mammary gland.
(2) Developments of growing ovarian follicles.
(3) Regulates female sexual behaviour
(4) Stimulates the development of secondary sex organs.
(5) Develop the high pitch of voice (Feminine voice)

Mechanism of Hormone Action

- **Protein Hormone Action : -**
  - → Interact with membrane bound receptors and forms hormone receptor complex leads to certain biochemical changes in the target tissue.
  - → These hormones do not enter the target cell but generate second messsenger like cAMP, IP_3 and Ca^{+2} etc.
  - → Examples :- Insulin, glucogon, pituitary hormones, hypothalamus hormones, epinephrine etc

- **Steroid Hormone Action : -**
  - → Interact with intracellular receptors.
  - → Mostly regulates gene expression or chromosome functions.
  - → Examples:- Cortisol, Testosterone, estradiol, Progesterone and thyroid hormones.


Hormone of nonendocrine tissue
Heart
Atrial natriuretic factor (ANF)
Dilates blood vessels, Cause B.P ↓
Kidney
Juxtaglomerular
(1) Erythropoietin
formation of RBC
(2) Renin
Increases reabsorption of water and Na ions in uriniferous tubules.
Gastro-intestinal tract
Gastrin
Stimulate the secretion of HCl and pepsinogen
Secretin
Stimulates secretion of water and bicarbonate ions.
Cholecystokinin
Stimulates the secretion of pancreatic juice and bile juice
Gastrointestinal peptides
Inhibit gastric secretion and motility.
Growth factor stimulate growth

PRINCIPAL ENDOCRINE GLANDS AND THEIR HORMONES

	Endocrine Gland and Hormone	Target Tissue	Principal Action
1	Posterior lobe of pituitary		
	Antidiuretic hormone (ADH)	Kidney tubules	Stimulates reabsorption of water, conserves water
	Oxytocin	Uterus	Stimulates contraction of uterus
		Mammary glands	Stimulates milk letdown
2	Anterior lobe of pituitary		
	Growth hormone (GH)	General	Stimulates growth
	Thyroid-stimulating hormone (TSH)	Thyroid gland	Stimulates secretion of thyroid hormones
	Gonadotropic hormones		
	(i) Luteinizing hormone (LH)	Sex organs	Stimulates ovulation (females); stimulates secretion of testosterone (males)
	(ii) Follicle-stimulating hormone (FSH)	Sex organs	Stimulates ovarian follicle (females) and sperm production (males)
	Adrenocorticotropic hormone (ACTH)	Adrenal cortex	Stimulates secretion of adrenal cortical hormones
	Prolactin (PRL)	Mammary glands	Stimulates milk production
	Melanocyte-stimulating hormone (MSH)	Melanin-producing cells	Controls pigmentation in some animals
3	Thyroid gland		
	Thyroid hormone (thyroxine)	General	Stimulates metabolic rate; essential to normal growth and development of CNS, Erythropoiesis.
	Calcitonin	Bone	Lowers blood calcium by inhibiting loss of calcium from bone

4	Parathyroid glands		
	Parathyroid hormone (PTH)	Bone, kidneys, digestive tract	Increases blood calcium levels by stimulating bone breakdown, stimulates calcium reabsorption from in kidneys; activates vitamin D
5	Adrenal medulla		
	Epinephrine and norepinephrine	Muscle, cardiac muscle, blood vessels	Intiate stress response; increase heart rate, blood pressure, metabolic rate; dilae blood vessels; mobilize fat strores, raise blood sugar levels.
6	Adrenal cortex		
	Aldosterone	Kidney tubules	Maintains proper balance of sodium and potassium ions in blood
	Cortisol	General	Aids in adaptation to long-term stress; raises blood glucose levesl; mobilizes fat stores; stimulates carbohydrate metabolism; acts to raduce
7	Pancreas (islets of Langerhans)		
	Insulin	General	Lowers blood glucose levels; increases storage of glycogen
	Glucagon	Liver, fat tissue	Raises blood glucose levels; stimulates breakdown of glycogen in liver
8	Ovary		
	Estrogens	General female reproductive structures	Stimulate development of secondary sexual characteristics and growth of sex organs at puberty; prompt monthly preparation of uterus for pregnancy
	Progesterone	Uterus	Completes preparation of uterus for pregnancy
		Mammary glands	Stimulates development
9	Testis		
	Testosterone	General	Stimulates development of secondary sexual characteristics and growth spurt at puberty
		Male reproductive structure	Stimulates development of sex organs stimulates production of sperm
10	Pineal gland		
	Melatonin	Sex organs, pigment cells	Function not well understood; influences pigmentation in some animals; may control biorhythms in some animals; may help control onset of puberty in humans.
11	Thymus		
	Thymosin	T-lymphocytes	Stimulates maturation and differentiation of T-cells

SEXUAL REPRODUCTION IN FLOWERING PLANTS

1. FLOWER :

Flowers are objects of aesthetic senses, ornamental, social, religious and cultural values.

Flowers are morphological embryological marvels and site of sexual reproduction in Angiosperms.

In the opinion of biologist as two of the four parts, Androecium and gynoecium are the important or sexual part of the plants.

A flower is a modified shoot for reproduction.

Flowers bears reproductive organs where gametes are produced. Androecium represents the male reproductive organ and it consist of two part→ (1) Anther (2) Filament

A typical anther is bilobed, dithecous and tetrasporangiate. Two microsporangia are present in each lobe of anther.

After maturation two microsporangia of each lobe fused togather, hence mature anther has two microsporangia.

2. Microsporangia :

Microsporangia surrounded by four layers–

(i) Epidermis– outer single celled thick layer.

(ii) Endothecium – It helps in dehiscence of anther.

(iii) Middle layer – it stores food.

(iv) Tapetum – nutritive. It is diploid/polyploid.

3. Microsporogenesis :

During the sporogenesis, every cells of sporogenous tissues (microspore mother cell) can give rise to tetrad of microspores through meiosis. Normally tetrad of microspores are tetrahedral in shape. Each microspore mature into pollen grain.

4. Pollen grain :

Pollen grains are bilayered in structure. Its outer layer is exine. It is made up of sporopollenin which is highly biological resistant material.

Inner layer is made up of pectocellulose. Germ pores are present on exine. The viability of pollen grains depends on temperature and humidity.

5. Microgametogenesis :

After germination, mature pollen grain contain two cells–

(A) Bigger is vegetative cell with large nucleus

(B) Smaller cell is generative cell with small nucleus.

Some times it is three celled stage. Generaly pollen grains shed at two celled stage.

Pollen grain can be stored for many years in liquid nitrogen (–196°) in pollen banks.

6. Carpel/Pistil :

Carpel is unit of gynoecium and consist of three part–

(i) Stigma

(ii) Style

(iii) Ovary – one/many ovules attached with placenta inside the ovary

7. Ovule :

Ovule represents integumented megasporangium. Ovule consist of funicle, integument; nucellus and an opening is called micropyle.

Most primitive type of ovule of angiosperm is orthotropous and most common is anatropous.

8. Megasporogenesis :

Formation of megaspores is called megasporogenesis.

During the process only one cell of the nucellus [Micropylar] differentiate into megaspore mother cell. Megaspore mother cell [MMC] undergoes meiotic division to produce four megaspores. In most of flowering plants, three megaspores [Micropylar] degenerate and remaining one [Chalazal] becomes functional megaspore.

9. Megagametogenesis :

The nucleus of functional megaspore undergoes three mitotic division to form 8 nucleated stage [Free nuclear division]. After cytokinesis, 7-celled and 8-nucleated female gametophyte or embryosac is formed. Out of the seven cells, three at micropylar end form- Egg apparatus [Two synergids and one egg cell]. Three cells towards the chalazal end are called antipodals. The large central cell has two polar nuclei. In a typical angiosperm, mature embryosac is seven celled and eight nucleated stage.

10. Pollination :

The transfer of pollen grains from anther to the stigma is called pollination.

Pollination is of three types–

(i) **Autogamy** – Pollination within the same flower.

(ii) **Geitonogamy** – Pollination in between the two different flowers of the same plant.

(iii) **Xenogamy** – Pollination in between two different flowers of the two different plant.

Pollination involve two type of pollination agents–

- [A] **Abiotic** →
  - Anemophily – **Grasses, Pinus** and **Coconut** etc.
  - Hydrophily – **Vallisneria, Hydrilla** etc.
- [B] **Biotic** →
  - Entomophily – **Amorphophallus, Yucca** etc.
  - Ornithophily – Sunbird – **Bignonia**
  - Chiropterophily – **Anthocephalus, Kigelia** etc

11. Fertilization :

After pollination, pollen grains germinate on the stigma and form pollen tube which enter inside the ovule generally through micropyle then it enter inside the embryosac towards the egg apparatus. Finally both of the male gametes discharged in the cell of synergids. Out of them one male gamete fused with egg cell and to form zygote [syngamy]. Second male gamete fused with secondary nucleus and to form triploid primary endosperm nucleus [Triple fusion].

Due to syngamy and triple fusion; Angiosperms exhibit double fertilization Zygote develops at micropylar end and it forms Embryo.

Primary endosperm nucleus develops into endosperm.

Formation of endosperm always precedes development of embryo.

During the development of embryo it passes through the various stage such as quadrant stage, octant stage globular stage, heart shaped stage and mature embryo.

Early stage of development of embryo are similar in monocot and dicots.

Mature embryo of dicots has two cotyledons and an embryonal axis.

Embryo of grass family (monocots) has single cotyledon or scutellum with embyonal axis, after formation of mature embryo, ovule develop into seeds and ovary develops in to a fruit.

Endosperm may either be completely consumed by developing embryo before seed matruration are called nonendospermic seed **Pea, Groundnut, Beans** or it may Persist in the mature seed are called endospermic seeds. **Castor, Coconut** etc.

12. Asexual reproduction/Apomixis :

The formation of new individuals without fertilization is called asexual/apomixis.

Apomixis is of two types–

(A) Agamospermy – Formation of embryos/seed without fertilization

(B) Vegetative propagation

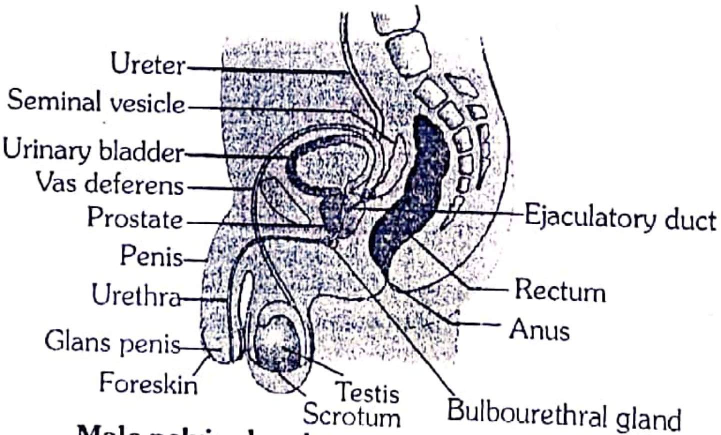
In some of the angiosperms more than one embryos are formed inside the seed is called polyembryony [Leeuwenhoek- **Citrus**].

Persistent nucellus is called perisperm eg **Black pepper, Beet** etc.

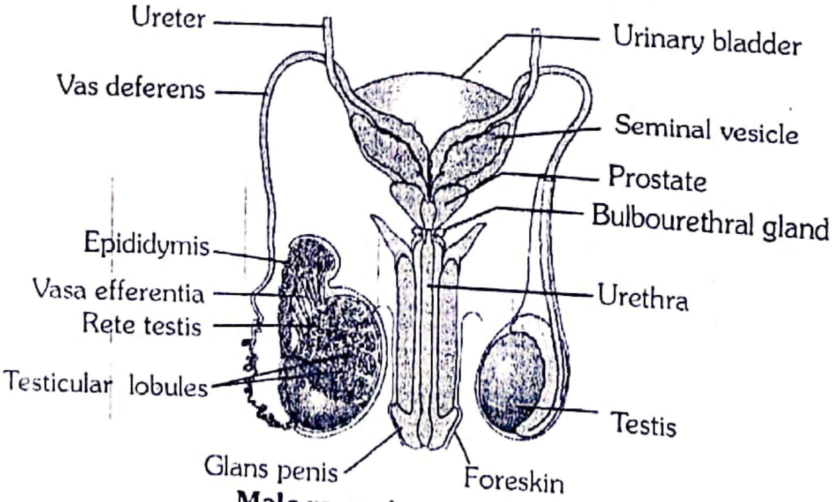
Male reproductive System –

Male reproductive organs
- Primary (Gametes forming organ)
  - Testes (Situated in extra abdominal Cavity) or Scrotum (2 – 2.5°c lower than normal body temp.)
- Secondary
  - Epididymis
  - Vasdeferens
  - Seminal Vesicle
  - Prostate
  - Bulbourethral gland
  - Penis

Testis ↓ internally testicular lobules (250)
- In interstitial spaces
  - In interstitial spaces ↓ Contain Small blood Vessels and interstitial cells or Leydig's cells ↓ Synthesis androgens
  - other immuno-competent cells (phagocytic cells)
- Seminiferous tubules in each lobules
  - Male germ cells (spermatogonia) ↓ Mitotic & Meiotic div. ↓ Sperms
  - Sertoli cells ↓ Provide nutrition to germ cells (spermatogonia)


Ureter
Seminal vesicle
Urinary bladder
Vas deferens
Prostate
Penis
Urethra
Glans penis
Foreskin
Testis
Scrotum
Bulbourethral gland
Ejaculatory duct
Rectum
Anus

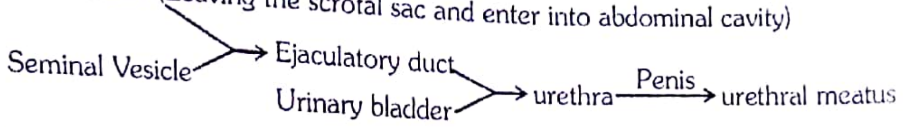
Male pelvis showing reproductive system


Ureter
Vas deferens
Epididymis
Vasa efferentia
Rete testis
Testicular lobules
Glans penis
Foreskin
Urinary bladder
Seminal vesicle
Prostate
Bulbourethral gland
Urethra
Testis

Male reproductive system

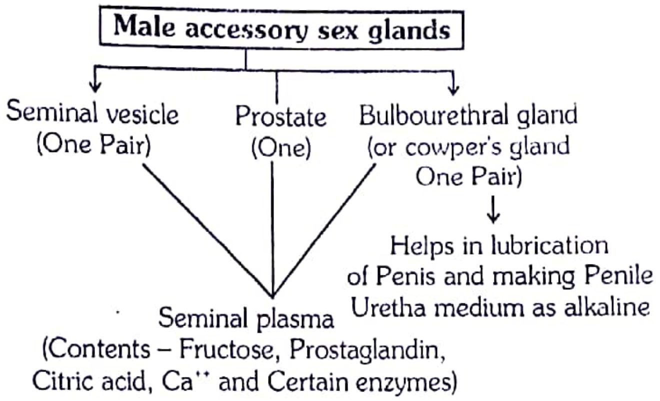
Male Sex accessory ducts

→ Rete testes (inside the testis)
↓
→ Vasa efferentia (Leaving the testis)
↓
→ Epididymis (Out side of testis)
↓
→ Vasdeferens (Leaving the scrotal sac and enter into abdominal cavity)

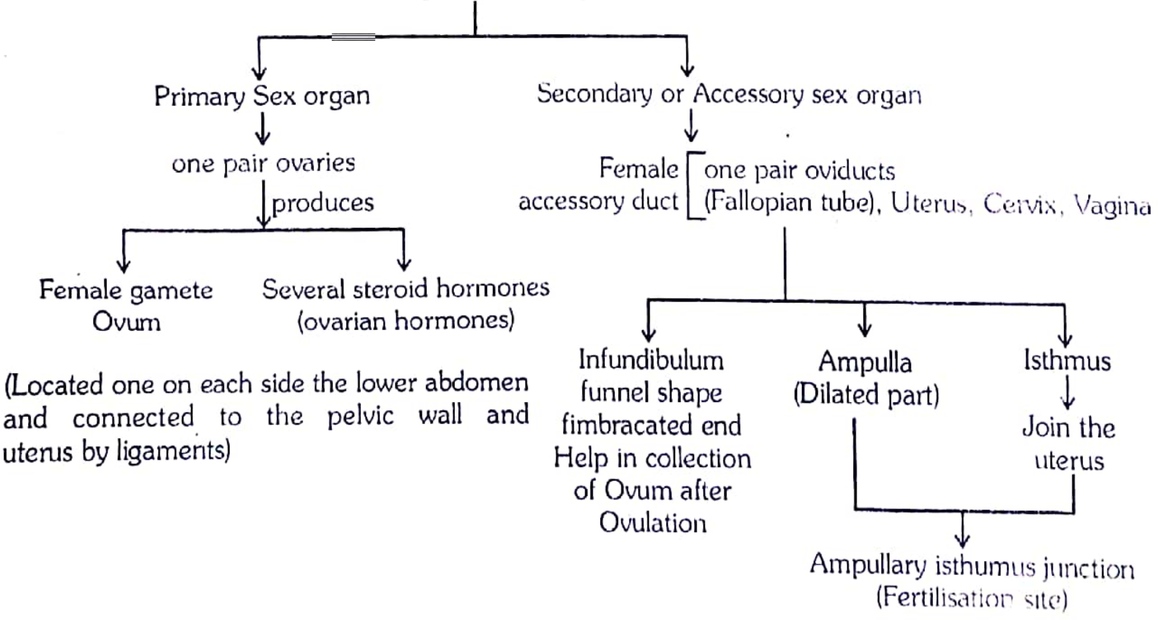

Seminal Vesicle
Ejaculatory duct
Urinary bladder
urethra
Penis
urethral meatus

Penis → External genitalia(made up of special tissue that helps in erection of the penis to facilitate insemination)
↓
Terminal bulge part → Glans penis is covered by a loose fold of skin (Foreskin)

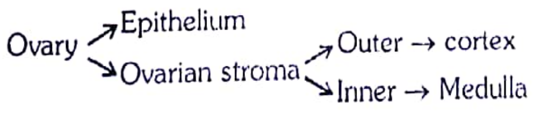
Male accessory glands


Male accessory sex glands
Seminal vesicle
(One Pair)
Prostate
(One)
Bulbourethral gland
(or cowper's gland
One Pair)
Helps in lubrication
of Penis and making Penile
Uretha medium as alkaline
Seminal plasma
(Contents – Fructose, Prostaglandin,
Citric acid, Ca^{++} and Certain enzymes)

Female reproductive system


Primary Sex organ
one pair ovaries
produces
Female gamete
Ovum
Several steroid hormones
(ovarian hormones)
Secondary or Accessory sex organ
Female accessory duct
one pair oviducts
(Fallopian tube), Uterus, Cervix, Vagina
Infundibulum
funnel shape
fimbracated end
Help in collection
of Ovum after
Ovulation
Ampulla
(Dilated part)
Isthmus
Join the
uterus
Ampullary isthumus junction
(Fertilisation site)

(Located one on each side the lower abdomen and connected to the pelvic wall and uterus by ligaments)


Ovary
Epithelium
Ovarian stroma
Outer → cortex
Inner → Medulla

uterus or womb → shape - Inverted pear shape, supported by ligaments attached to the pelvic wall.

uterus $\xrightarrow[\text{cervical canal}]{\text{cervix or}}$ Vagina or

Vagina + Cervix = Birth Canal

wall of uterus

- External thin membranous → Perimetrium
- Middle thick layer of smooth muscels → Myometrium → exhibits strong contraction during delivery of baby
- Inner glandular layer → endometrium
  - lines the uterine cavity
  - Cyclical changes during menstrual cycle

External genitalia of Female or Vulva → Include

- Mons Pubis → Cushion of fatty tissue covered by skin and pubic hair
- Labia majora → Fleshy Folds of tissue and surround the Vaginal opening
- Labia minora → Paired Folds of tissue under the L. majora
- Clitoris → Tiny finger like structure which lies at the upper junction of the two labia minora above the urethral opening

Opening of the vagina covered partially by a memb. → Hymen → broken after first coitus, sudden fall, insertion of a vaginal tampon, Some sports like horse riding, cycling etc.

In some women the hymen persists even after coitus in margin of vaginal opening.

Infact, the presence of absence of hymen is not a reliable indicator of virginity or sexual experience.

Developed mammary glands or Breasts – A paired structures contain glandular tissue variable amount of fat.

Breast

↓ Divided

into 15 – 20 mammary lobes

↓

cluster of cells or Alveoli → secretes milk

↓

Open into mammary tubules

↓

tubules of each lobe Join to form a mammary duct

↓

Ampulla → Lactiferous duct → open in nipple

Gametogenesis

- Male → Testis
- Female → Ovaries

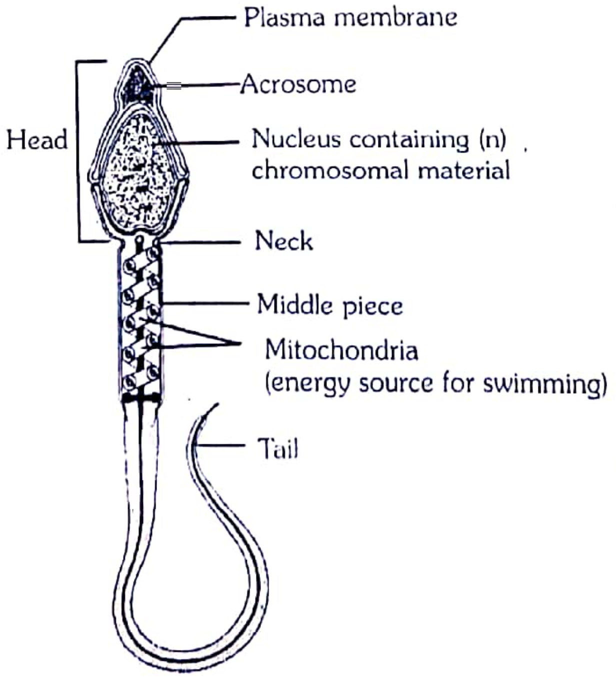
Spermatogenesis :

(Seminiferous tubules)
Spermatogonium (2n)
↓ Mitotic div.
Spermatogonium
↓ Growth
Primary spermatocyte (2n)
↓ Ist Meiotic div.
Secondary spermatocyte (n)
↓ IInd Meiotic div.
Spermatid (n)
↓ Spermiogenesis
Spermatozoa (sperms)

After spermiogenesis, sperm heads become embedded in the sertoli cells and are finally released from seminiferous tubules by process called spermiation.

Hypothalamus
↓ GnRH
Anterior pituitary

- L.H. or I.C.S.H
  ↓
  Leydig's cells
  ↓
  Androgen (Testosterone)
- F.S.H.
  ↓
  Sertoli Cells
  ↓
  Stimulates Secretion of some factors which help in the process of spermiogenesis


Plasma membrane
Acrosome
Head
Nucleus containing (n) chromosomal material
Neck
Middle piece
Mitochondria (energy source for swimming)
Tail

Structure of a sperm

The human male ejaculates about 200-300 million sperms during a coitus of which at least 60% sperms must have normal size and shape and 40% of them must show vigorous motility.

Semen [Seminal plasma = Secretion of epididymis, Vasdeferens, Seminal Vesicle and prostate(maintained by the testicular hormones - androgens)
+
Sperms (Essential for maturation and motility of sperms)

Oogensis (Process of formation of a mature female gamete)

Oogonia (No more Oogonia are formed and added after birth)

↓

Primary Oocyte in primary follicle

(Ist Meiotic prophase)

60,000 – 80, 000 primary follicle at Puberty

(Layers of granulosa cells surround the primary oocyte)

↓

The primary follicle gets surrounded by more layers of granulosa cells and a new theca and are called secondary follicles.

↓

Tertiary follicle

(Antral Cavity or antrum formed)

(Ist meiotic div. completed and Sec. Oocyte formed)

↓

Mature tertiary follicle or Graafian follicle

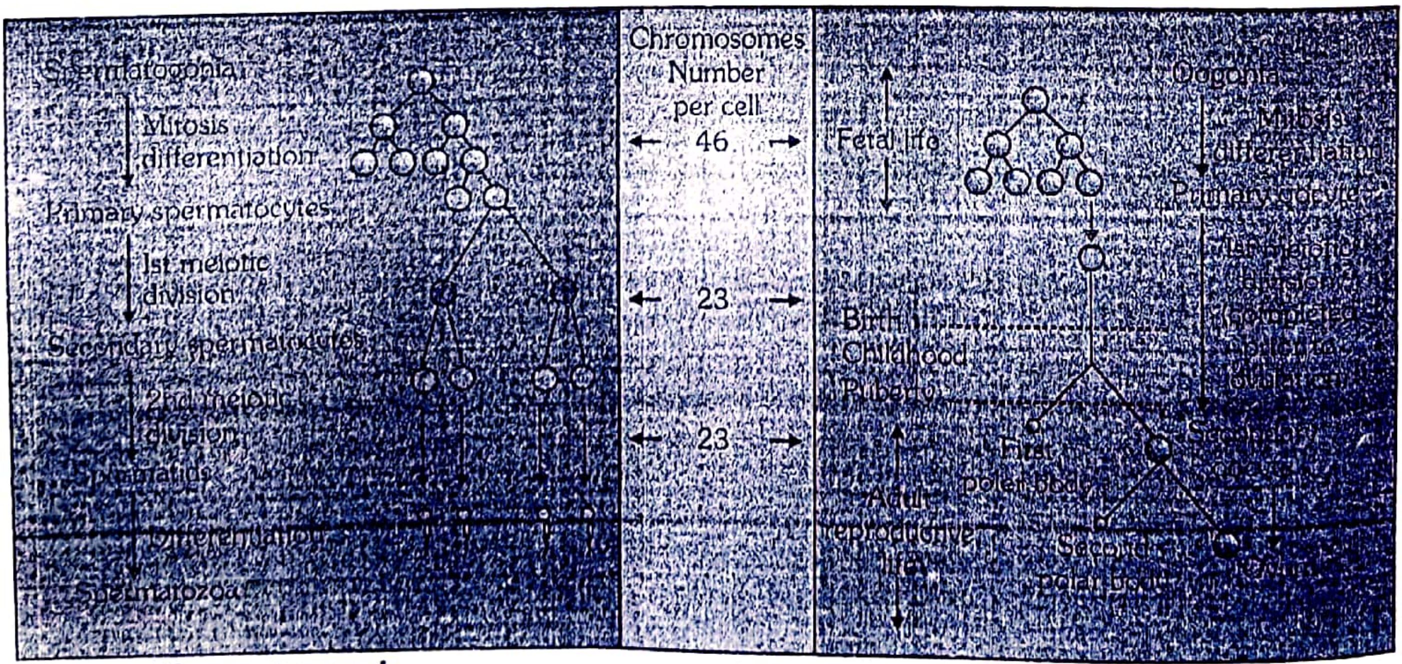
the secondary oocyte forms a new membrane called zona pellucida.

↓

Rupture Graafian follicle

↓

Ovulation (Release of secondary oocyte from ovary)

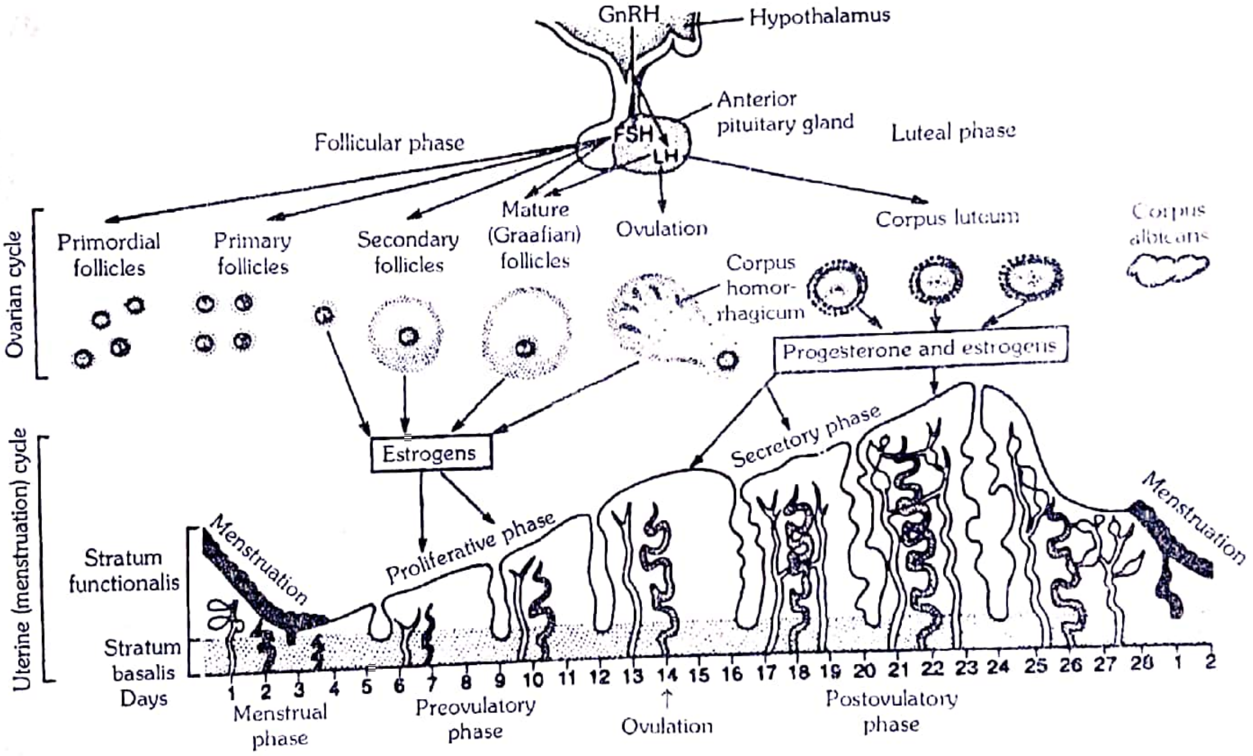

Spermatogonia
Mitosis differentiation
Primary spermatocytes
Ist meiotic division
Secondary spermatocytes
2nd meiotic division
Spermatids
Differentiation
Spermatozoa
Chromosomes Number per cell
46
23
23
Fetal life
Birth
Childhood
Puberty
Adult reproductive life
Oogonia
Mitosis differentiation
Primary oocyte
1st meiotic division completed prior to ovulation
Secondary oocyte
First polar body
Second polar body
Ovum

Spermatogenesis **Oogenesis**

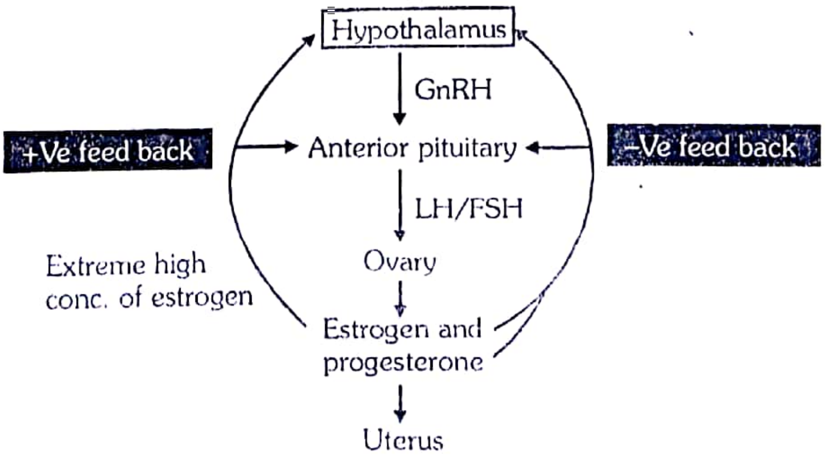
Menstrual cycle (28/29 days)

First menstruation begins at puberty and is called menarche

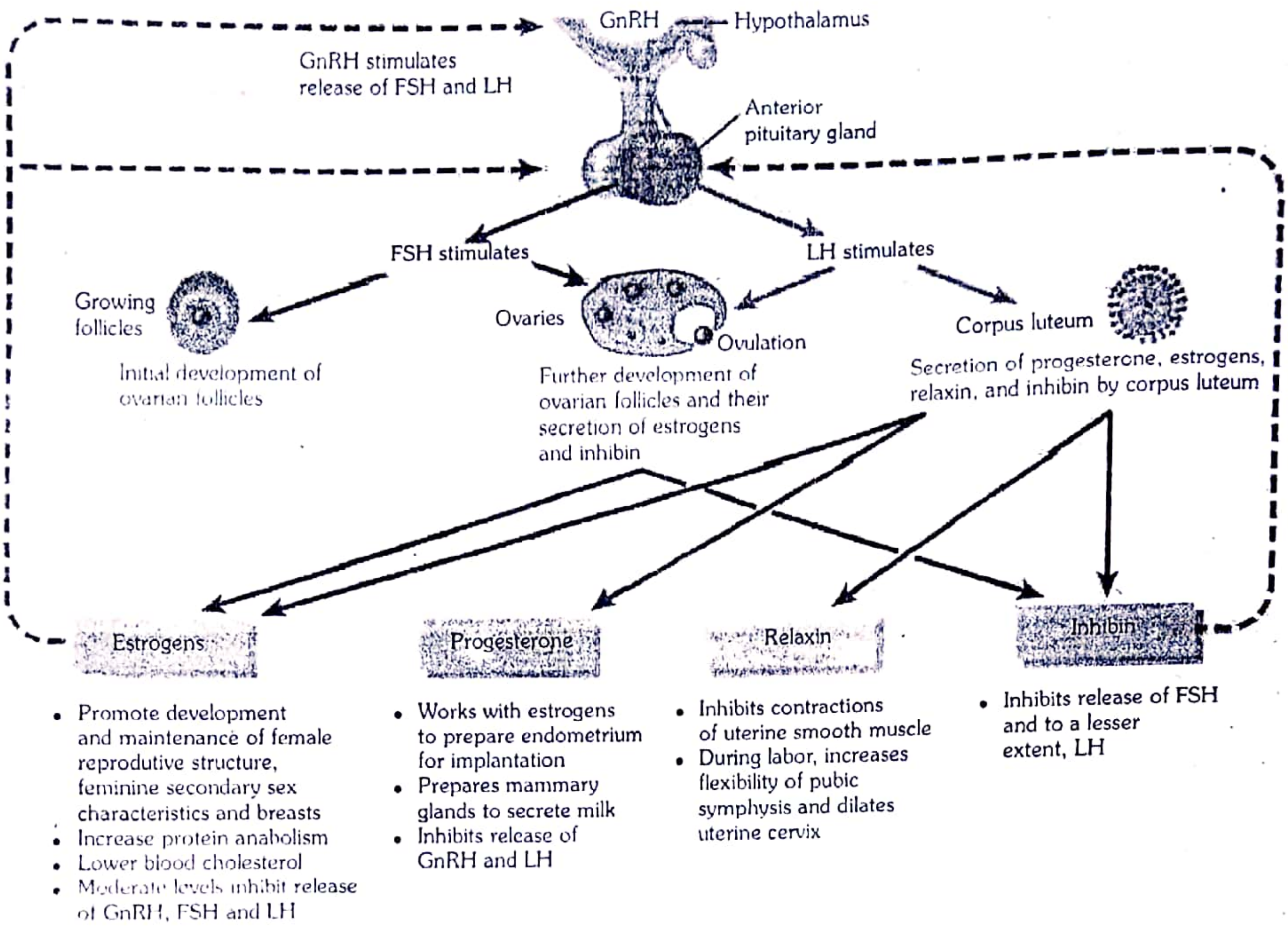
Hypothalamus
↓ GnRH
Anterior pituitary
↓ F.S.H. ↓ L.H.

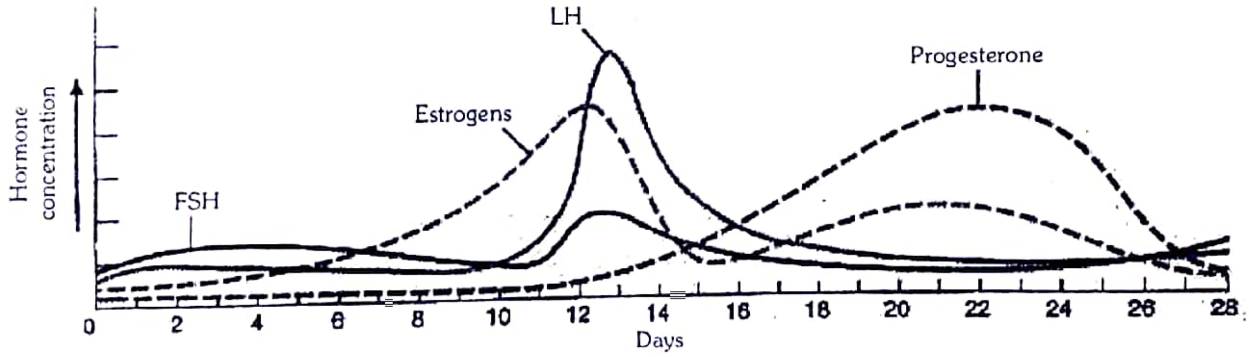

GnRH
Hypothalamus
Anterior pituitary gland
FSH
LH
Follicular phase
Luteal phase
Ovarian cycle
Primordial follicles
Primary follicles
Secondary follicles
Mature (Graafian) follicles
Ovulation
Corpus homorrhagicum
Corpus luteum
Corpus albicans
Progesterone and estrogens
Estrogens
Uterine (menstruation) cycle
Stratum functionalis
Stratum basalis
Days
Menstruation
Proliferative phase
Secretory phase
Menstruation
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 1 2
Menstrual phase
Preovulatory phase
Ovulation
Postovulatory phase

Schematic representation of menstrual cycle


Hypothalamus
GnRH
+Ve feed back
Anterior pituitary
-Ve feed back
LH/FSH
Ovary
Extreme high conc. of estrogen
Estrogen and progesterone
Uterus

(Flow chart of female hormones)


GnRH
Hypothalamus
GnRH stimulates release of FSH and LH
Anterior pituitary gland
FSH stimulates
LH stimulates
Growing follicles
Initial development of ovarian follicles
Ovaries
Ovulation
Further development of ovarian follicles and their secretion of estrogens and inhibin
Corpus luteum
Secretion of progesterone, estrogens, relaxin, and inhibin by corpus luteum
Estrogens
Progesterone
Relaxin
Inhibin
• Promote development and maintenance of female reprodutive structure, feminine secondary sex characteristics and breasts
• Increase protein anabolism
• Lower blood cholesterol
• Moderate levels inhibit release of GnRH, FSH and LH
• Works with estrogens to prepare endometrium for implantation
• Prepares mammary glands to secrete milk
• Inhibits release of GnRH and LH
• Inhibits contractions of uterine smooth muscle
• During labor, increases flexibility of pubic symphysis and dilates uterine cervix
• Inhibits release of FSH and to a lesser extent, LH

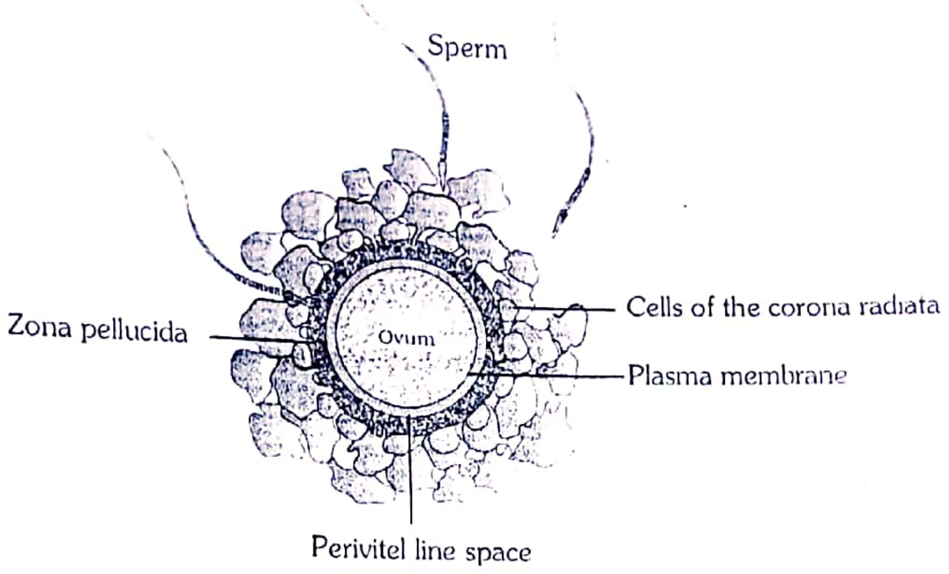


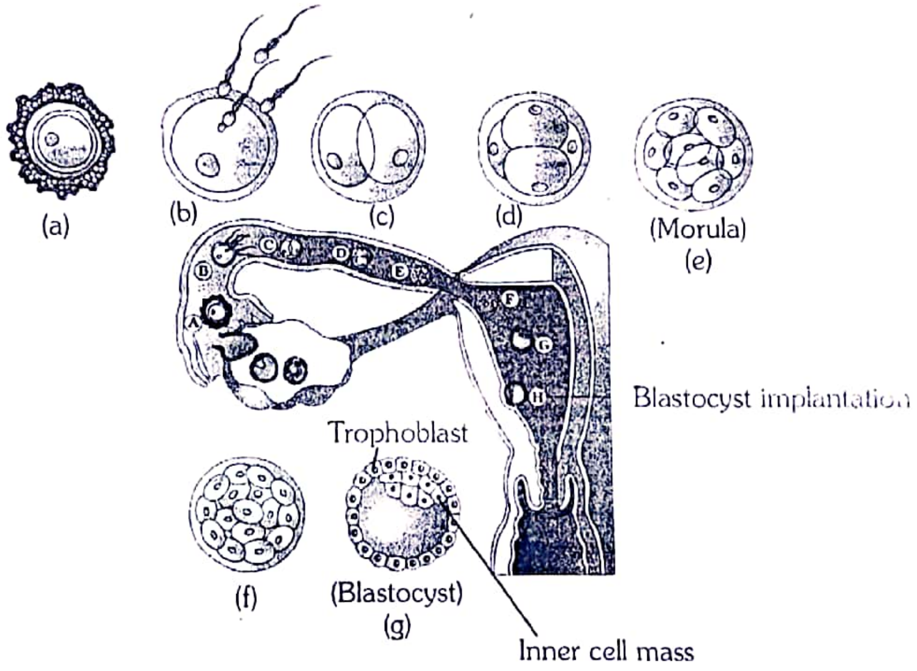
Changes in concentration of anterior pituitary and ovarian hormones

Menopause –

Menstrual cycles ceases around 50 years of age.

During Copulation (Penis)
↓ Semen
Vagina
↓
Cervix
↓
Uterus
↓ Sperms motile
Ampullary Isthmus Junction
(Fertilization)


Sperm
Cells of the corona radiata
Zona pellucida
Ovum
Plasma membrane
Perivitel line space


(a)
(b)
(c)
(d)
(Morula)
(e)
A
B
C
D
E
F
G
H
Blastocyst implantation
Trophoblast
(f)
(Blastocyst)
(g)
Inner cell mass

After implantation :

Chorionic villi + uterine tissue(endometrium) = Placenta (Structural and functional unit between developing embryo and maternal body).

Functions – Respiration, Excretion and nutrient medium

$$\text{Embryo} \xrightarrow{\text{Umblical cord}} \text{Placenta}$$

Endocrine medium – HCG, HPL, Estrogen, Progestron, relaxin etc.

– HCG, HPL and relaxin are produced in women only during pregnancy.

Embryonic development –

During Pregnancy

First Month – Heart beating

Second Month – Limbs and digits developed

12 Weeks -- Most of the major System are formed

5 Month – First movements of faetus and appearance of scalp of hairs

24 weeks – Find body hairs, eyelids separated and eye lashes formed

9 Month -- Fully developed foetus and ready for delivery.

Gestation period (about 9 month)

Delivery of foetus (child birth) → Parturition
↓
induced by a complex neuroendocrine mechanism
Fully developed foetus or mature placenta
↓
Triggers release of Oxytocin
↓
Uterine Contraction
↓
Relaxin released by ruptured placenta
↓
Birth Canal wide and move towards the outside
↓
Baby delivered

After parturition → Mother starts producing milk → Lactation → Colostrum (first milk) → Contains high Conc. of antibodies (I_gA) → Essential for development and Growth of healthy baby.

REPRODUCTIVE HEALTH (PROBLEMS & STRATEGIES)

Population explosion and Birth control

Growth of population

Increased health facilities & better living conditions.

World population

1900	2 billion
2000	6 billion

India

1947 – 35 crore (350 million)

May 2000 – 1 billion (Every sixth person is an Indian)

Probable reason :

(1) Rapid decline in death rate

(2) MMR (Maternal mortality rate)

(3) IMR (Infant mortality rate)

(4) Increase in number of people in reproducible age.

RCH programme (Reproductive & child health care) :

Bring down the population growth rate it was only marginal.

Census – Population growth rate

2001 – 1.7% (17/1000/year)

(Rate at which over population could double in 33 years)

This alarming growth rate lead to scarcity of food, shelter, Clothing.

Types of Contraceptive methods :

Natural / Traditional
Barrier
IUDs
Oral contraceptives
Implants
Surgical methods.

Natural method :

Periodic abstience – Avoiding coitus during unsafe period

Withdrawal coitus interruptus – Withdrawal of penis from vagina just before ejaculation.

Lactational amenorrhea – This method is effective only upto a maximum period of six month following parturition.

Barrier method :

Condom : Made up of latex sheath (Both male and female condom)
It is used to cover penis & ejaculate semen remain in condom & not enter in female reproductive tract.

Diaphram, cervical cap and vaults : are made up rubber, used to cover the cervix during coitus.

Intra uterine device (IUD) :

Non medicated IUDs (Lippes loop) – Increase phagocytosis of sperms within the uterus.

Copper releasing IUDs (CUT, CU7, Multiload 375) – Suppress sperm motility.

Hormone releasing IUDs (Progestasert, LNG - 20) – Make uterus unsuitable for implantation & cervix hostile to sperm.

Oral contraceptive pills (OCP) :

Contain small doses of either progestogens or progestogen - estrogen combination inhibit ovulation.

Daily pills – Male D, Mala N (Taken daily from 5th day to 21 days after gap of 7 days again repeated)

Weekly pill – Saheli / Centachroman (Non steroidal, very fews sideffect) and high controceptive value.

Injection or Implants : Mode of action is similar to pills effective is much longer.

Surgical method / Terminal method :

Male – Vasectomy
Females – Tubectomy

Infertility : Couple unable to produce children inspite of unprotected sexual co-habitation.

Assisted reproductive technologies (ART)

(1) In vitro fertilisation (IVF) : fertilisation is done outside the body.

ZIFT (Zygote intra follopian transfer) – Zygote or early embryo (Upto 8 blastomers) is transfered into the fallopian tube.

IUT (Intra uterine transfer) / Test tube bady :

Embryo with more than 8 blastomere (commonly 32 blastomeres) is transfered into the uterus.

ICSI (Intra cyloplasmic sperm injection) :

Sperm is injected into the ovum & then transfered into the fallopian tube.

(2) In vivo fertilisation : Fusion of gametes within the female.

GIFT (Gamete intra fallopian transfer) :

Ovum collected from a donar is transfered into the fallopian tube of another female.

Artificial insemination :

Semen collected either from the husband or a healthy donar is artifiacilly introduced either into the vagina or uterus of the female.

It is performed when male partner is unable to inseminate the female or sperm count is very low.

GENETICS

(Principles Of Inheritance & Variation, Variation, Moleculear Basis of inheritance)

- Genetics deals with the inheritance, as well as the variation of characters from parents to offsprings.
- Inheritance is the process by which characters are passed on from parent to progeny.
- Variation is the degree by which progeny differs from their parents.

GENETICAL TERMS :

- **Genes (Factors) :** They are the units of inheritance, which contain the information that is required to express a particular character, in an organism.
- **Alleles :** Genes which code for a pair of constrasting traits and present on a same locus on the homologous chromosome, are known as alleles. i.e. They are the slightly different forms of the same gene.
- **Homozygous (Pure) :** Identical pair of alleles (TT or tt)
- **Heterozygous (Hybrid) :** Dissimilar pair of alleles (Tt)
- **Phenotype :** External & morphological appearance of character.
- **Genotype :** Genetic make up of an organism.
- **Punnett square :** It is a graphical representation to calculate the probability of all possible genotypes of offspring in a genetic cross.

MENDELISM :-

- Gregor Johann Mendel, conducted hybridization experiments on garden pea (***Pisum sativum***).
- He studied seven pairs of contrasting characters.

S.No.	Characters	Dominant/Recessive	Chromosome No.
1	Seed/Cotylodeon colour	Yellow / Green	1st
2	Flower colour	Violet / White	1st
3	Pod Shape	Inflated / Constricted	4th
4	Flower position	Axial / Terminal	4th
5	Stem length / Height	Tall / Dwarf	4th
6	Pod colour	Green / Yellow	5th
7	Seed shape	Round / Wrinkled	7th

- Mendel uses Emasculation, Bagging & Tagging technique for hybridization.

Inheritance of one gene (Monohybrid Cross)

- Study of inheritance of one character at a time in an organism is called as monohybrid cross.
- Phenotypic / Mendelian Ratio = 3 : 1
- Genotypic / Real Ratio = 1 : 2 : 1
- **Conclusions of monohybrid cross :**
  (i) Postulate of Dominance :
  - Characters are controlled by discrete units called factors.
  - Factors occur in pairs.
  - In a dissimilar pair of factors one member of the pair dominates the other.
  - A dominant allele is wild type or unmodified allele, which produces normal enzyme/protein, that forms a character.

- A modified allele is a mutant allele, which could be responsible for the production of less-efficient enzyme or non-functional enzyme or no enzyme at all. Thus it will be a recessive allele.

(ii) Law of segregation (Law of purity of gametes) :

- This law is based on the fact that the alleles do not show any blending and that both the characters are recovered as such in the F_2 generation.
- Though the parents contain two alleles, during gamete formation, the factors or alleles of a pair segregate from each other such that a gamete receives only one of the two factors. **Thus gametes are always pure.**
- The 3 : 1 ratio obtained in F_2 is mainly due to segregation, although there is the role of dominance also

Inheritance of two genes (Dihybrid cross) :

- Study of inheritance of two characters at a time, in an organism in called as dihybrid cross.
- Phenotypic ratio = 9 : 3 : 3 : 1
- Genotypic ratio = 1 : 2 : 1 : 2 : 4 : 2 : 1 : 2 : 1
- **Conclusion of dihybrid cross :**

  (i) Law of independent assortment :

  - This law states that when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters.
  - Each character is inherited in monohybrid pattern (3 : 1).
  - It is applicable only when both the genes are present of separate homologous pair of chromosome.

Important formulae (Applicable in case of selfing only)

- 2^n = Type of gamets / Type of phenotypes
- 3^n = Type of genotypes
- 4^n = Total possible number of zygote
- [n = Number of heterozyous condition].

Back cross :

- It is a cross of F_1 individuals with any of their parents.
- It is of two types :

  (i) Out cross : F_1 individual × Homozygous dominant parent.
  Phenotypic ratio = All dominant
  Genotypic ratio = 1 : 1 (For monohybrid cross)

  (ii) Test cross : F_1 individual × Homozygous recessive parent.
  It is used to find out the genotype of F_1 individual.
  Phenotypic ratio = 1 : 1 (For monohybrid cross)
  Genotypic ratio = 1 : 1 (For monohybrid cross)

Reciprocal cross :

- A pair of crosses in which male & female sexes are reversed.
- In Mendelian cross, results of reciprocal crosses were same.

GENE INTERACTIONS :

It is of two type :

1. Allelic interactions / Intragenic interactions

(i) Incomplete dominance :

F_1 phenotype did not resemble either of the two parents & was in between the two.

Phenotypic & Genotypic ratio = 1 : 2 : 1

e.g. Flower colour in ***Mirabilis jalapa*** & **Antirrhinum** (Snapdragon).

Starch grain size in ***Pisum sativum***.

(ii) Co-dominance :

F_1 phenotype resembles both parents but donot blending.

Phenotypic & Genotype ratio = 1 : 2 : 1

e.g. Coat colour in cattles.

AB blood group ($I^A I^B$)

Carrier of sickle cell anaemia ($Hb^A Hb^S$)

(iii) Multiple Alleles :

Existence of more than two alleles of a gene, called as multiple alleles.

Since in an individual only two alleles can be present, multiple alleles can be found only when population studies are made.

Number of possible genotype = $\frac{n(n+1)}{2}$ [n = number of alleles]

e.g. Blood group inheritance in human = 3 alleles.

(iv) Lethal genes :

They affect viability of an organism & causes death in homozygous condition.

Phenotypic ratio becomes 2 : 1 instead of 3 : 1.

e.g. Coat colour in mice

Leaf colour in Snapdragon

Sickle cell anaemia in human.

(v) Pleiotropic genes :

Genes which controls more than one character.

e.g. Most of genetical disorders / syndrome in human.

In pea plant, single gene influence seed coat colour, Flower colour & red spot in leaf axil.

In pea plant, single gene influence seed shape & size of starch grains.

2. Non-Allelic interactions / Intergenic interactions :

(i) Epistasis :

When a gene prevents the expression of another non-allelic gene.

(a) Dominant epistasis : e.g. Hair colour in Dogs,
Phenotypic ratio = 12 : 3 : 1

(b) Recessive epistasis : e.g. Coat colour in mice
Phenotypic ratio = 9 : 3 : 4

e.g. Leaf colour in Rice; Phenotypic ratio = 13 : 3

(ii) Complementary gene :

e.g. Flower colour in **Lathyrus**; Phenotypic ratio = 9 : 7

(iii) Supplementary genes :

e.g. Coat colour in mice; Phenotypic ratio = 9 : 3 : 4

POLYGENIC INHERITANCE :

- Inheritance of characters in which one character is controlled by many genes.
- Intensity of character depends on number of dominant allele i.e. dominant allels are contributory in nature
- Contribution of a dominant allele $= \dfrac{\text{Max. expression} - \text{Min. expression}}{\text{Total number of dominant alleles}}$

e.g. Kernal colour of wheat = 2 genes (Ratio = 1 : 4 : 6 : 4 : 1)

Skin colour of human = 3 genes (Ratio = 1 : 6 : 15 : 20 : 15 : 6 : 1)

CYTOPLASMIC INHERITANCE (By C.Correns)

- It is the inheritance of those characters which are controlled by cytogenes.
- This inheritance occurs only through female (also called maternal inheritance). Thus reciprocal cross results will be affected.
- It is mainly due to some cell organelles like plastids & mitochondria (Organellar inheritance).

e.g. Plastid inheritance in *Mirabilis jalapa*.

Male sterility in Maize (Mitochondrial)

CHROMOSOMAL THEORY OF INHERITANCE :

By Walter Sutton & Theodore Boveri

- They noted that the behaviour of chromosomes was parallel to the behaviour of genes & used chromosome movement to explain Mendel's laws.
- A comparison between behaviour of chromosome & genes :

A (Gene)	B (Chromosome)
Occur in pairs	Occur in pairs
Segregate at the time of gamete formation such that only one of each pair is transmitted to a gamete	Segregate at gamete formation and only one of each pair is transmitted to a gamete
Independent pairs segregate independently of each other	One pair segregates independently of another pair

- The experimental verification of chromosomal theory of inheritance was done by T.H. Morgan & his colleagues.

LINKAGE & RECOMBINATION :

- Inheritance of genes in group is called linkage.
- Linked genes are located on same chromosome & all the genes located on one pair of homologous chromosome form one linkage group.
- In linkage, the proportion of parental gene combinations are much higher than the non-parental type.
- Tightly linked genes shows very low recombination while loosely linked genes shows higher recombination.
- Linked genes may have either cis arrangement [AB & ab] or trans arrangement [Ab & aB].
- Linkage may be complete (C.O. absent) or incomplete (C.O. present).
- % Recombination / Recombination frequency $\propto$ Distance between genes.
- % Recombination $= \dfrac{\text{Number of recombinant organisms}}{\text{Total organisms}} \times 100$ [1 % CO = 1 centi Morgan (cM)]

SEX LINKAGE (By Morgan)

- Genes present on sex chromosomes shows sex linkage.

- It is of three types :
  - (i) **X-linkage :** Genes present on non-homologous region of X-chromosome, shows X-linkage.
    e.g. Colourblindness, Haemophilia, Eye colour in *Drosophila*
  - (ii) **Y-linkage :** Genes present on non-homologous region of Y-chromosome, shows Y-linkage.
    e.g. SRY or TDF gene, Hypertrichosis
  - (iii) **X-Y linkage :** Genes present on homologous region of X & Y chromosome, shows X-Y linkage.
    e.g. Xeroderma pigmentosum, Epidermolysis bullosa.
- Sex linked characters shows two types of inheritance.'
  - (i) Criss cross inheritance
    - Diagenic ⇒ Father → Daughter → Grandson
    - Diandric ⇒ Mother → Son → Grand daughter
  - (ii) Non-criss-cross inheritance
    - Hologynic ⇒ Mother → Daughter → Grand daughter
    - Holandric ⇒ Father → Son → Grandson

SEX DETERMINATION :

- Establishment of sex through differential development in an individual at an early stage of life.

(1) Allosomic determination of sex :

Sex chromosomes are responsible for sex determination.

(a) XX (♀) – XY (♂) type (Lygaeus type) : e.g. Human, *Drosophila, Coccinea* & *Melandrium plants.*

(b) XY (♀) – XX (♂) type [or ZW - ZZ type] : e.g. Birds, Fishes, Reptiles & *Fragaria plant.*

(c) XX (♀) – XO (♂) type [Protenor type] : e.g. Grasshopper, Cockroach, Ascaris.

(2) Genic Balance theory (By C.B. Bridges)

- It is given on the basis of *Drosophila.*
- In this sex determination takes place by sex index ratio.

$$\text{Sex index ratio (SIR)} = \frac{\text{Number of X-chromosome}}{\text{Number of sets of Autosome}} = \frac{X}{A}$$

If SIR = 1 → Female
= 0.5 → Male
= > 1 → Super female
= <0.5 → Super male
= 0.5 – 1 → Intersex

(3) Environmental determination of sex :

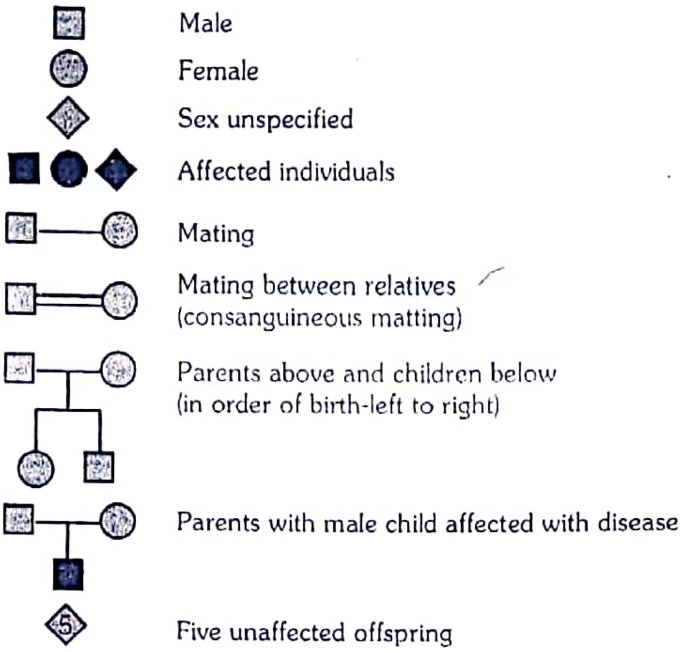
e.g. *Bonellia, Crepidula,* Crocodile, Turtles etc.

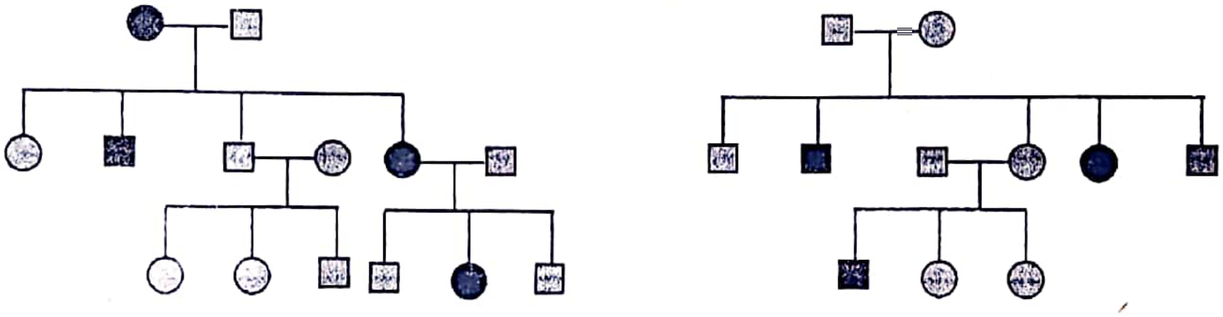
(4) Sex determination by hormone :

Sex hormone are required for sex differentiation. It can be observed in **Free martin** development in cattles.

- In honey bee, ants etc. Haploid (♂) – Diploid (♀) method found.
- Gynandromorph (Half ♂ & Half ♀ body) in *Drosophila* is due to loss of one X-chromosome during first zygotic division.
- Cytological basis of sex determination – Formation of Barr body in Mammalian ♀.

- Study of the family history for the inheritance of particular trait in several generation of a family is called the pedigree analysis.
- In pedigree analysis, symbols are used for study. Some of the important standard symbols used in the pedigree analysis are as follows :


Male
Female
Sex unspecified
Affected individuals
Mating
Mating between relatives
(consanguineous matting)
Parents above and children below
(in order of birth-left to right)
Parents with male child affected with disease
5
Five unaffected offspring



(a) (b)

Figure : Representation of Pedigree analysis of
(a) Autosomal dominant trait (for example - Myotonic dystrophy)
(b) Autosomal recessive trait (for example - Sickle cell anaemia)

POPULATION GENETICS :

- Study of gene frequency in a population is called population genetics.
- Gene frequency : It is the proportion of different alleles of a gene in a population.
- **Hardy-Weinberg law :**

  In a large, randomly mating population, the frequency of a gene remain constant from generation to generation when factors like selection, mutation & migration are absent.

  According to this law, $\boxed{p+q=1}$

  p = frequency of dominant allele
  q = frequency of recessive allele

  $$\boxed{p^2+2pq+q^2=1}$$

  Here, p^2 = frequency of homozygous dominant organisms.
  $2pq$ = frequency of heterozygous organisms.
  q^2 = frequency of homozygous recessive organisms.

DNA FINGERPRINTING / DNA PROFILING / DNA TEST :

- It is the technique to identify a person on the basis of his/her DNA specificity.
- Invented by - **Sir Alec Jeffery** (1984)
- It involves identifying difference in some specific regions in DNA sequence called as **repetitive DNA.**
- These repetitive DNA are separated from bulk genomic DNA as different peaks during density gradient centrifugation.
- The bulk DNA forms a major peak & the other small peaks are referred to as **satellite DNA.**
- The satellite DNA is classified into many categories such as minisatellites, microsatellites etc. These sequence show high degree of polymorphism & form the basis of DNA fingerprinting.
- Minisatellites are 11-60 bp long repetitive sequence, where number & position is variable in each chromosome & also person to person. So they are also known as VNTR (Variable Number of Tendem Repeats)
- VNTR in a DNA is flanked by restriction site & known as restricted fragment.
- The length of restricted fragment of each chromosome/DNA is variable & this is known as RFLP (Restricted fragment length polymorphism).
- The fingerprinting technique is based on RFLP.
- The DNA fingerprinting technique includes following steps :
  - (i) Isolation of DNA.
  - (ii) Digestion of DNA by restriction endonucleases.
  - (iii) Separation of DNA fragments by electrophorosis.
  - (iv) Transferring of separated DNA fragments to synthetic membranes such as nitrocellulose or nylon (southern blotting).
  - (v) Hybridization using labelled VNTR probe.
  - (vi) Detection of hybridized DNA fragments by autoradiography.
- The autoradiogram gives many bands of different sizes.
- It differs from individual to individual in a population except in case of **monozygotic twins.**
- This technique is very useful in **forensic science, paternity testing,** in determining population & genetic diversity.

CLONING :-

- Formation of clones is cloning.
- Clone is group of genetically identical organisms.
- Asexual or vegetative reproduction produces natural clones.
- Cloning can be done artificially. It may be **Gene cloning, Microbial / Cell cloning, Plant cloning** or **Animal cloning.**
- Animal cloning is difficult & not so direct as in plants, because animal cells looses totipotency in early embryonic stage.
- Animal cloning may be

  (i) Reproductive cloning (ii) Therapeutic cloning.
- In reproductive cloning, a clone of whole animal is developed. It have three techniques :
  - (i) Blastomere separation technique.
  - (ii) Nuclear transplantion technique.
  - (iii) Honolulu technique.

- In therapeutic cloning only desired organs are produced form cells of patient. This is very useful in medical science.
- "Dolly' sheep was produced by using nuclear transfer technique by **Dr. Ian Wilmut** at Roslin institute of Scotland in 1997.
- Cloning technique is useful for transgenic organisms (GMO), improved animal breeds and endangered species.

HUMAN GENOME PROJECT (HGP) :

- Study of genome is known as **Genomics.**
- HGP was called a mega project, launched in 1990 for sequencing of human genome.
- This 13-year project was coordinated by **U.S. Department of Energy** & **The National Institute of Health.** The project was completed in 2003.
- Some of important goals of HGP were as follows :
  - (i) Identify all the genes in human DNA.
  - (ii) Determine the sequences of the 3 billion base pairs that make up human DNA.
  - (iii) Store this information in database.
  - (iv) Improve tools for data analysis (Development of Bioinformatics).
  - (v) Transfer related technologies to other sectors such as industries.
  - (vi) Address the ethical, legal & social issues (ELSI) that may arise from the project.
- In HGP, many non-human model organisms, such as bacteria ***(Haemophilus influenzae)***, Yeast, ***Caenorhabditis elegans*** (nematode), ***Drosophila***, Plants (***Rice*** & ***Arabidopsis***) have also been sequenced.
- The methods in HGP involved two major approaches :

(1) **Expressed Sequence Tags (EST) :** Identifying all the genes that expressed as RNA.

(2) **Sequence Annotation :** It is the blind approach of simply sequencing the whole set of genome that contained all coding & non-coding sequence & later assigning them with functions.

- The sequencing was done by automated DNA sequencers that worked on principle of a method developed by Frederick Sanger.
- BAC & YAC was the common vectors used in HGP.
- The sequence of chromosome-1 was completed in May-2006 (this was last of 24 human chromosomes studied).

Salient features of human genome :

(i) Human genome contains 3164.7 million nucleotides bases.

(ii) Average gene size - 3000 bases.

Largest gene : Dystrophin gene of X-chromosome (2.4 million bases)

Smallest gene : SRY/TDF gene of Y-chromosome (14 bp).

(iii) Total number of genes is estimated 30,000.

(iv) 99.9% nucleotide bases are exactly same in all people.

(v) Functions of more that 50% genes discovered is unknown.

(vi) Less than 2% of genome codes for proteins.

(vii) Repeated sequences make up large portion of human genome.

(viii) Chromosome-1 has maximum genes (2968) & Y-chromosome has fewest (231).

(ix) **SNPs** (Single nucleotide polymorphism) : 1.4 million locations where single base difference exist.

Gene library :

It is a collection of many of the desired genes. The DNA fragments are maintained in clones of bacterial or some other cells.

Gene Bank :

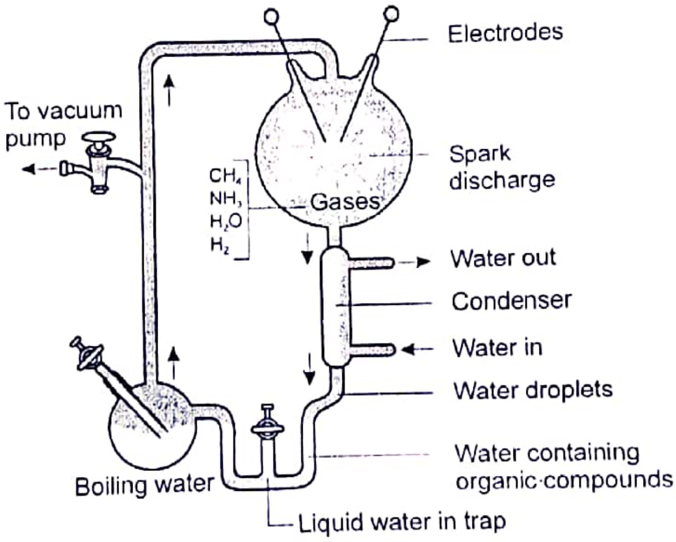
It is a store house of clones of DNA fragments, genes, genes maps, seeds, spore, sperms, eggs or embryos.

Bioinformatics :

It is the application of computer technology to the management of biological information.

EVOLUTION (ORIGIN AND EVOLUTION)

- Evolutionary biology is the study of history of life forms on earth.
- Universe originated about 20 billion years ago by thermo-nuclear explosion called Big-Bang.
- Earth originated about 4.5 billion year ago.
- Stellar distances are measured in light years.
- Life appeared 500 million years after the formation of eath i.e. almost four billion years back.
- According to theory of spontaneous generation life came out of decaying and rotting matter like straw, mud etc
- Louis pasteur by careful experimentation demonstrated that life comes only from pre-existing life.
- Oparin and Haldane propsoed that the first form of life could have come from pre-existing non living organic molecules and that formation of life was preceded by chemical evolution.
- To prove chemical evolution in 1953, Miller created electric discharge in a closed flask containing CH_4, H_2, NH_3 and water vapour at 800°C. He observed formation of amino acids.



Diagrammatic representation of Miller's experiment

- The first non cellular forms of life could have originated 3 billion years ago.
- Theory of special creation has three connotations–
  - All living organisms that we see today were created as such.
  - The diversity was always the same since creation and will be the same in future.
  - The earth is about 4000 years old.
- All these ideas were strongly challenged during the nineteenth century based on observations made during a sea voyage in a sail ship called H.M.S. Beagle round the world, Charles Darwin concluded that existing living forms share similarities to varying degrees not only among themselves but also with life forms that existed millions of years ago.

The fitness, according to Darwin, Refene ultimately and only to reproductive fitness

Alfered Wallace a naturalist who worked in malay Archipelago.

- According to 'Panspermia theory' unit of life called 'spores' were transferred to different planets including earth
- The geological history of earth closely correlates with the biological history of earth

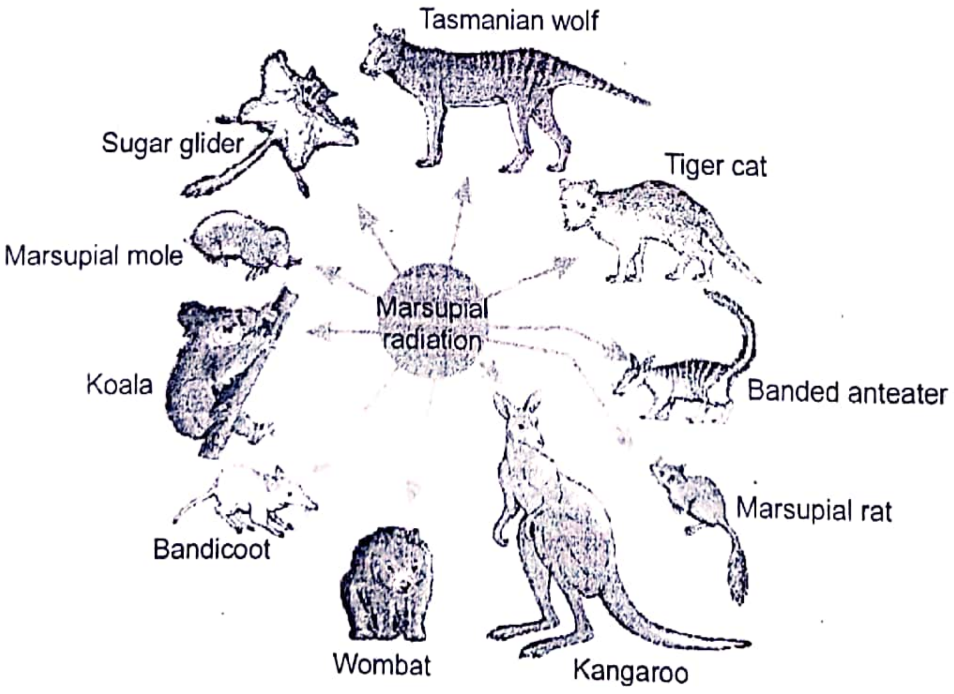
- Fossils are remains of hard parts of life forms found in Rocks.

  Different aged rock sediments contain fossils of different life foms who probably died during the formation of the particular sediment.

  Fossils represent extinct organism (e.g. Dinosaurs) Paleontology - study of fossils.
- Homology present in organisms shows divergent evolution and analogy shows convergent evolution.
- The same structure developed along different divergent evolution and these structures are homologous. Homology indicates common ancestory.

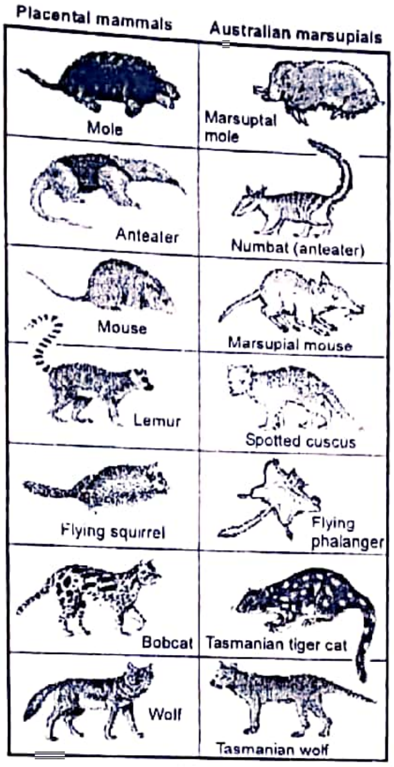
  e.g. – Forelimbs of all mammals.
  – Visceral organs of vertebrates like heart, brain.
  – Thorn and tendrils of Bougainvillea and cucurbita.
- Analogous structures are a result of convergent evolution. Different structures evolving for the same function. Similar habitat has resulted in selection of similar adaptive features in different groups of organisms.

  e.g. – Eyes of octopus and mammals.
  – Flippers of Penguins and Dolphins.
  – Wings of butterfly and birds.
  – Potato and Sweet potato.
- Proteins and genes performing a given function among diverse organisms give clues to common ancestry.
- According to industral melanisation phenomenon in a mixed population, those that can better adapt, survive and increase in a population size. No variant is completely wiped out.
- Evolution is not a direct process in the sense of determinism, it is a stochastic process (probable proces) based on chance event is nature and chance mutation in the organisms.
- The process of evolution of different species in a given geographical area strarting from a point and radiating to other areas of geography (habitats) is called as adaptive radiation. For eg. Darwin's Finches and Marsapials of Australia.



Adaptive radiation of marsupials of Australia

- When more than one adaptive radiation appeared to have occured in an isolated geographical area (representing different habitats). One can call this convergent evolution.


Placental mammals
Australian marsupials
Mole
Marsuptal mole
Anteater
Numbat (anteater)
Mouse
Marsupial mouse
Lemur
Spotted cuscus
Flying squirrel
Flying phalanger
Bobcat
Tasmanian tiger cat
Wolf
Tasmanian wolf

Picture showing convergent evolution of Australian Marsupials and placental mammals

- According to darwinism adaptive ability is inherited. It has a genetic basis. Fitness is the end result of the ability to adapt and get selected by nature.
- **Branching descent** (adaptive radiation) and **natural selection** are the two key concepts of Darwinism.
- According to lamarckism evolution of forms had occured but driven by use and disuse of organs.
- When the original driffed population becomes founders and the effect is called founder effect.
- Mutations are random and directionless while darwinian variations are small and directional.
- De-vries called mutation as saltation (single step large mutation).
- During evolution the first organism were plants.
- By the time of 500 million years ago, invertebrates were formed and active.

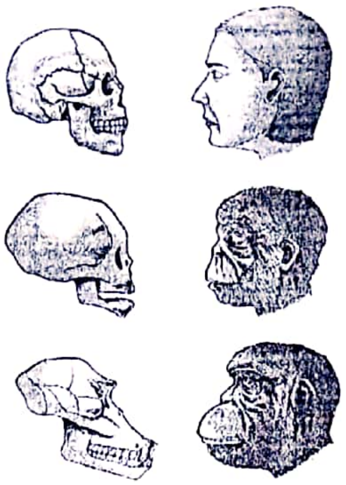
  * Jawless fish probably evolved around 350 million years ago.

  * Sea weeds and few plants existed probably around 320 million years ago.

  * In 1938, a fish caught in South Africa happened to be a Coelacanth which was through to be extinct. These animals called lobe fins evolved into the first amphibians.

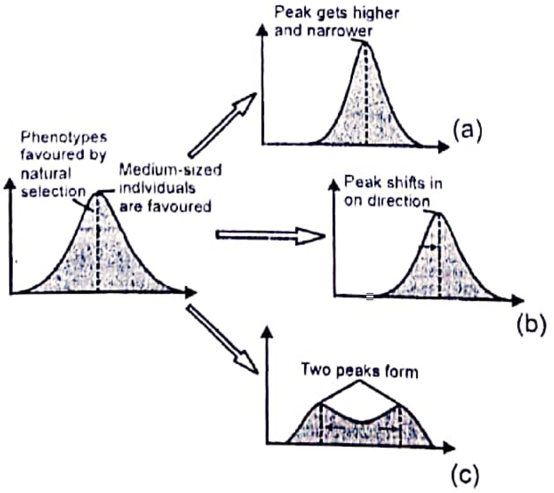
  * Some of the land reptiles went back into water to evolve into fish like reptiles probably 200 million years ago (eg. Ichthyosaurs).
- The biggest dinosaur was *Tyrannosaurus rex*, about 20 feet.
- About 65 million years ago the dinosaurs suddenly disappeared from the earth.
- The first mammals were like shrews.

- Ramapithecus was more man like while Dryopithecus was more ape like.



A comparison of the skulls of adult modern human being, baby chimpanzee and adult chimpanzee. The skull of baby chimpanzee is more like adult human skull than adult chimpanzee skull

- During evolution first human like being was homo-habilis.
- Agriculture was started before 10,000 years.
- Approx. 2 million years ago Australopithecus probably lived in East African grassland.
- Cranial capacity – Homo habilis – 650 –800 CC., Probably did not eat meat.
  Homo erectus – 900 CC., Probably ate meat.
  Neanderthals – 1400 CC., Lived in near East and central Asia between 10,0000 - 40,000 yrs back.
- Pre-historic cave art developed about 18000 years ago.
- Three types of natural selection–
  - Stabilising selection – The peak gets higher and narrower.
  - Directional selection – Peak shifts in one direction.
  - Disruptive selection – Two peaks form.


Peak gets higher and narrower
(a)
Phenotypes favoured by natural selection
Medium-sized individuals are favoured
Peak shifts in on direction
(b)
Two peaks form
(c)

Diagrammatic representation of the operation of natural selection on differenttraits : (a) Stabilising (b) Directional and (c) Disruptive

HUMAN HEALTH & DISEASE

Health → State of complete physical, mental and social well-being

Affected by
1. Genetic disorders
2. Infections
3. Life style

- Awareness about diseases
- Vaccination / immunisation
- Proper disposal of wastes
- Control of vectors
- Maintenance of hygienic food
- Maintenance of water resources etc..

are necessary for achieving good health

Maintenance requires
1. Balanced diet
2. Personal hygiene
3. Regular exercise (Yoga)

Diseases

Infectious
Caused by pathogens
(Some parasites are pathogens)

- → ***Salmonella typhi*** → Causes typhoid, which is confirmed by **Widal test,** pathogen enters through contaminated food and water
- → ***Streptococcus pneumoniae*** or ***Haemophilus influenzae*** → Causes 'Pneumonia'
- → Rhino-viruses → Common cold
- → ***Plasmodium*** → Causes Malaria, Infections form is sporozoite, fever due to haemozoin, vector female ***Anopheles***
- → ***Entamoeba histolytica*** → Amoebiasis or Amoebic dysentery
- → ***Ascaris*** → Ascariasis
- → ***Wuchereria*** → Elephantiasis or Filariasis
- → ***Microsporum, Epidermophyton, Trichophyton*** → Causes Ring-worm
- → **AIDS :** HIV Virus

Non-infectious (Cancer)

Immunity
(Ability of host to fight the disease-causing organism)

Innate immunity

- Non-specific
- Consists of 4 types of barriers

(i) **Physical** = Skin, Mucosa

(ii) **Physiological** = Saliva, Tear, Gastric Juice

(iii) **Cellular** = PMNL-neutrophils, Monocytes, NK cells, Macrophages

(iv) **Cytokine** = Interferons

Acquired immunity

- Specific
- Charecterised by **Memory**

Active Immunity

- Natural active immunity
  - by infection
- Artificial active immunity
  - by infection

Passive Immunity

- Natural passive immunity
  Eg – IgG (placenta)
  IgA (Colostrum)
- Artificial passive immunity
  Eg Preformed Antibodies

Immune Response (I.R.)

Primary I.R.

- Low intensity, slow
- When body encounters the pathogen for first time

Secondary I.R.

- Highly intensified, rapid
- Subsequent encounter with same antigen
- Also called "**anamnestic response**"

Both carried out with 2 types of lymphocytes

T-lymphocytes

- Mediate cell-Mediated immunity
- CMI is responsible for rejection of transplanted organs

B-lymphocytes

- Produce antibodies (Igs) which has 2 light and 2 heavy chains, represented as H_2L_2.
- Anti bodies provide humoral immune response

Lymphoid organs
(Where origin, maturation and proliferation of lymphocytes occur)

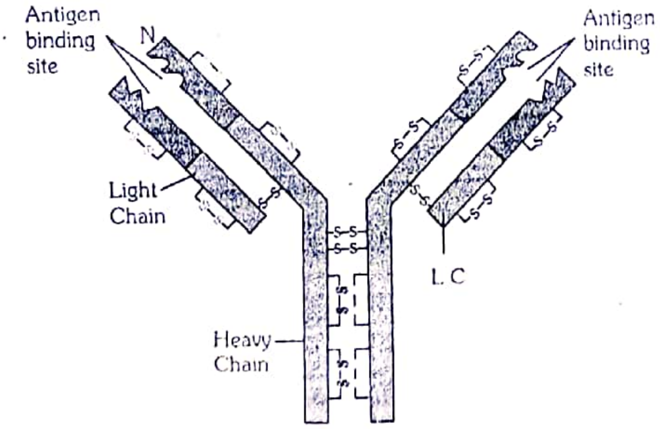
Primary Lymph Nodes (PLO)
↓
(Bone-marrow Thymus)

Immature lymphocytes → Antigen sensitive lymphocytes

Secondary Lymph Nodes (SLO)
↓
Spleen
Lymph-nodes
Tonsils
Payer's patches
Appendix
MALT [50%]
(Mucosa Associated Lymphoid Tissues)
↓
Provide sites for interaction of lymphocytes with the antigen

STRUCTURE OF ANTIBODY

It is produced by B-lymphocytes and help T-lymphocytes.



Vaccination and immunisation

- Principle of vaccination is based on memory.

  Preparation of antigenic proteins or inactivated / weakened pathogen → introduced in body → antibodies are produced → provide acquired artificial immmunity
- During tetanus or snake biting, preformed Igs / antitoxin is given. It is called **passive immunisation.**
- Hepatitis -B vaccine produced from **yeast** by Recombinant DNA technology.

Allergy

- Exaggregated response of immune response to certain antigens present in the environment.
- IgE antibodies are formed against allergens like mites in dust, pollens, animal dander etc.
- Symptoms = Sneezing, Watery eyes, running nose, difficulty in breathing etc.
- Allergy is due to Histamine + Serotonin secreted by mast cells. Antibodies produce during the allergy is IgE type. So antihistamine, adrenaline, steroids drugs are used for symptomatic relief.
- Metro cities life style has lowering immunity and more sensitivity to allergens.

Autoimmmunity

- When antibodies attack self cells or proteins due to genetic and other unknown reason, then it is called **autoimmunity.** eg. Rheumatoid arthritis.

AIDS (Acquired Immuno Deficiency Syndrome)

- **Not a congenital disease,** because deficiency of immune system, acquired during the life-time of an individual.
- Caused by HIV which is retrovirus.

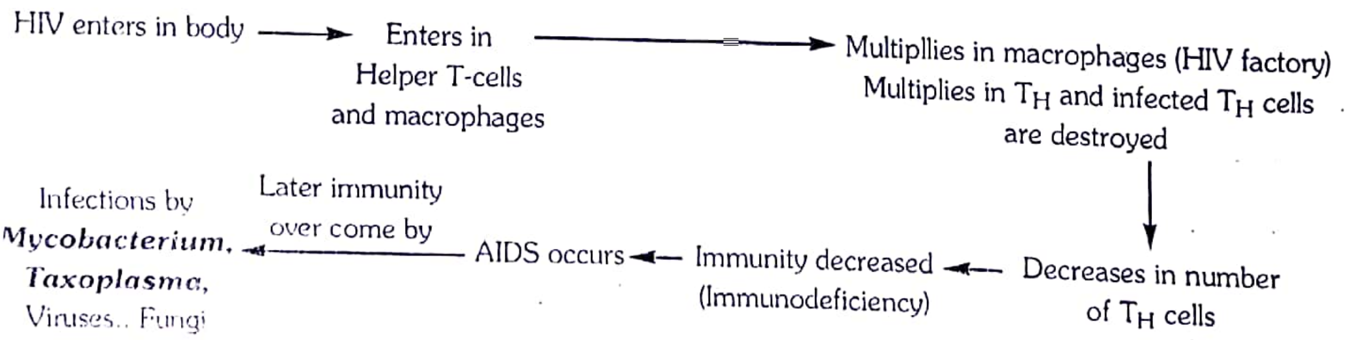
  HIV transmits :

  (a) by sexual contact with infected persons.

  (b) by transfusion of contaminated blood

  (c) by sharing needles (infected)

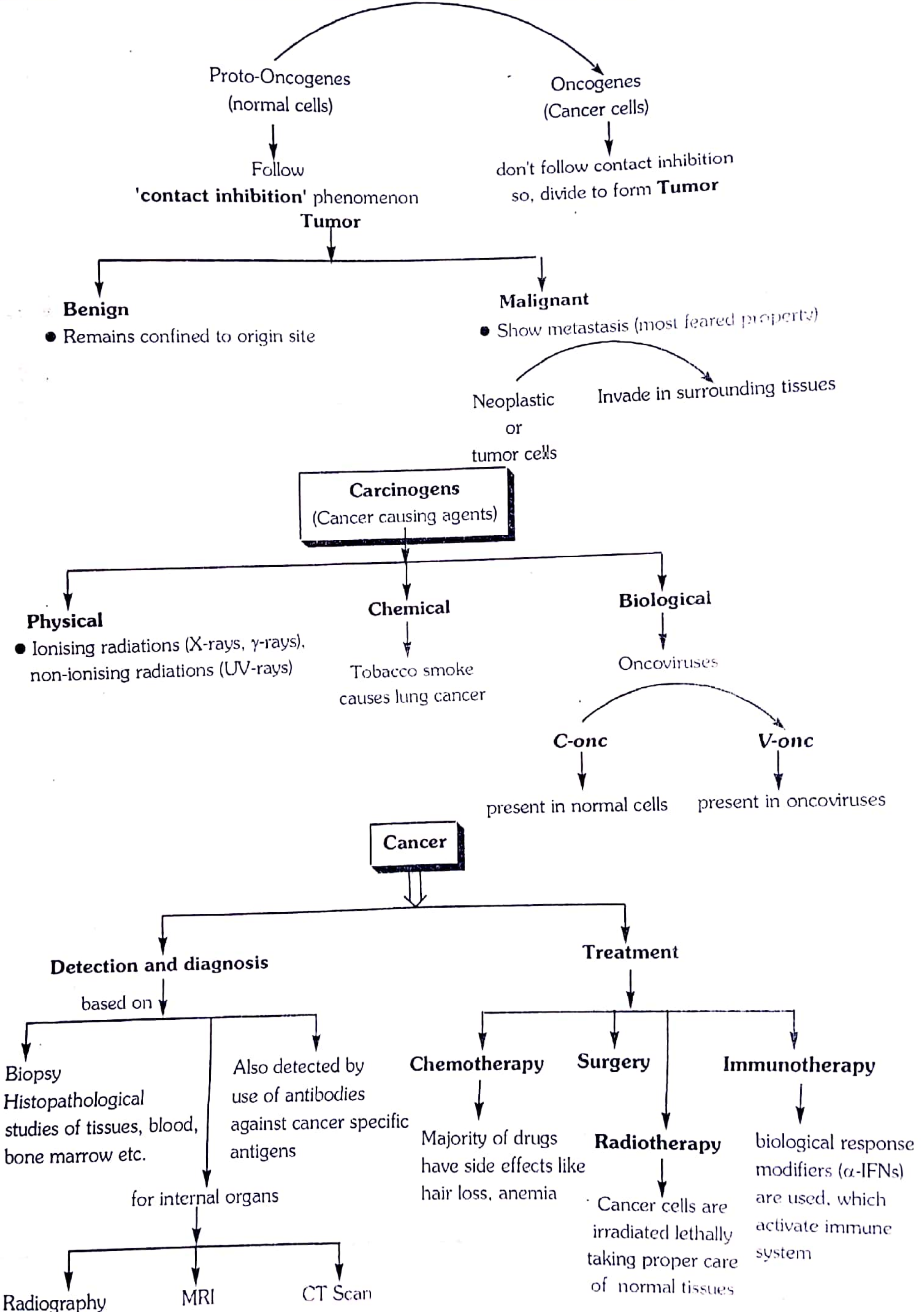
  (d) from infected mother to her child.
- HIV/AIDS is not spread = by mere touch or physical contact
- HIV spread "**only through body fluid**"
- **Incubation period** usually **5-10 years.**


HIV enters in body
Enters in Helper T-cells and macrophages
Multipllies in macrophages (HIV factory)
Multiplies in T_H and infected T_H cells are destroyed
Decreases in number of T_H cells
Immunity decreased (Immunodeficiency)
AIDS occurs
Later immunity over come by
Infections by *Mycobacterium*, *Taxoplasma*, Viruses., Fungi

- Diagnostic test is **ELISA (Enzyme Linked Immuno Sorbent Assay)**
- Treatment by anti-retroviral drugs.
- **AIDS has no cure so prevention is best.**

Cancer

- Most dreaded disease of human beings.
- Develops due to **Oncogenic transformation.**



Proto-Oncogenes (normal cells) → Oncogenes (Cancer cells)

Proto-Oncogenes (normal cells) → Follow **'contact inhibition'** phenomenon

Oncogenes (Cancer cells) → don't follow contact inhibition so, divide to form **Tumor**

Tumor

- **Benign**
  - Remains confined to origin site
- **Malignant**
  - Show metastasis (most feared property)
  - Neoplastic or tumor cells → Invade in surrounding tissues

Carcinogens (Cancer causing agents)

- **Physical**
  - Ionising radiations (X-rays, γ-rays), non-ionising radiations (UV-rays)
- **Chemical** → Tobacco smoke causes lung cancer
- **Biological** → Oncoviruses
  - **C-onc** → present in normal cells
  - **V-onc** → present in oncoviruses

Cancer

- **Detection and diagnosis** based on
  - Biopsy
  - Histopathological studies of tissues, blood, bone marrow etc.
  - Also detected by use of antibodies against cancer specific antigens
  - for internal organs
    - Radiography
    - MRI
    - CT Scan
- **Treatment**
  - **Chemotherapy** → Majority of drugs have side effects like hair loss, anemia
  - **Surgery**
  - **Radiotherapy** → Cancer cells are irradiated lethally taking proper care of normal tissues
  - **Immunotherapy** → biological response modifiers (α-IFNs) are used, which activate immune system

Drugs

Opioids

- Opioids receptors are present in CNS and GIT eg. **Heroin** and **Morphine**

Heroin:

- Diacetylmorphine
- White
- Odourless
- Bitter
- Crystalline
- Depressant

Morphine:

- Extracted From Latex of poppy plant ***(Papaver somniferum).*** It is effective sedative and painkiller, used during surgery

Cannabinoids

- Receptors present in Brain, natural cannabinoids are obtained from inflorescens of ***Cannabis sativa***

eg. Marijuana, Hashish, Charas, Ganja

Coca alkaloid

- Obtained from ***Erythroxylum coca*** (native to S.America),

eg. Cocain/Coke/Crack, it produces a sense of ***euphoria,*** high dose causes ***hallucination*** like ***Datura, Atropa belladona***

Other abused drugs

- Barbiturates
- Amphetamines
- Benzodiazepines
- LSD [most potent hallucinogen]

Smoking

- Tobacco contains **nicotine** (an alkaloid) which stimulates adrenal gland to release adrenaline + nor-adrenaline, due to this BP and heart rate increases.

Smoking Causes

- Cancer of lungs, Urinary bladder, Throat / Oral cacity
- Bronchitis
- Emphysema
- Coronary heart diseases
- Gastric Ulcer etc.

Adolescence

- "a period" and "a process" during which a child becomes mature in terms of attitude and belief for effctive participation in society.
- Period between 12–18 years
- Bridge linking **childhood** and **adulthood**

Drugs and Alcohol abuse

Cuases which motivates youngsters, towards drug and alcohol use are :

- Curiosity
- Need for adventure
- Excitement
- Experimentation
- Pressures to excel in academics/examination
- Perception of 'Cool/Progress'
- Unsupportive family structure or "**Peer pressure**"

Addiction :

- Becuase of perceived benefits, drugs are frequently used repeatedly
- It is psychological attachment of certain effects like '**Euphoria**'
- Use of drugs even once, can be a fore-runner to addiction.

Dependence :

- It is tendency of body to manifest a characteristic and unpleasant "**Withrawal syndrome**" if regular dose of drug / alcohol is abruptly discontinued, characterised by anxiety, vomiting, shakiness nausea & sweating.

Effects :

- Reckless behaviour
- Vandalism
- Voilence
- Respiratory failure, Heart failure and cerebral hemorrage can cause and death
- Abusers can acquire serious infections like AIDS, hepatitis-B etc.
- Liver cirrhosis
- Nervous system damaging

Prevention and Control :

- Avoid undue peer pressure.
- Education and counselling.
- Seeking help from parents and peers.
- Looking for danger signs.
- Seeking professional and medical help.

"PREVENTION IS BETTER THAN CURE"

STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION

DOMESTICATION OF PLANTS

- Recorded evidences of plant breeding dates back to 9000 – 11,000 years ago.
- The main step of plant breeding is–

  (1) Collection of variability

  (2) Evaluation and selection of parents

  (3) Cross hybridisation among the selected parents

  (4) Selection and testing of superior recombinants

  (5) Testing, release and commercialisation of new cultivars.
- Genetic variability is the root of any breeding programme.
- The entire collection (of plants/seeds) having all the diverse allele for all genes in a given crop is called germplasm collection.
- Agriculture accounts for approximately 33% of india's GDP and employs nearly 62 percent of the population.
- P–1542 is indian hybrid crop of pea.
- During the period 1960 to 2000, wheat production increased from 11 million tonne to 75 million tonnes while rice production went up from 35 million tonnes to 89.5 million tonnes.
- In 1963 **Sonalika, kalyan Sona,** which were high yielding and disease resistant varieties of wheat, were introduced in india.
- Semi dwarf rice variety **[IR–36],** which were derived from **IR–8** [developed at IRRI, philippines] and **taichung native-1** (from taiwan) introduced in india in 1966.
- **Jaya** and **Ratna** which are better yielding dwarf varieties of rice, later developed in india.
- ***Saccharum barberi*** (grown in north india) had poor sugar content and yield and saccharum officinarum (grown in south india) had thick stem and higher sugar content. By crossing of these two varieties we developed new varieties which have desirable qualities like high yield, thick stem, high sugar. [Nobal sugarcane]
- The conventional Method of breeding for disease resistance is hybridisation and selection.
- Some crop varieties developed by hybridisation and selection for disease resistance→

Breeding for disease resistance

Crop	Variety	Resistance to diseases
Wheat	Himgiri	Leaf and stripe rust, hill bunt
Brassica	*Pusa swarnim* (Karan rai)	white rust
Cauliflower	*Pusa shubhra,* *Pusa snowball K-1*	Black rot and curl blight black rot
Cowpea	*Pusa Komal*	Bacterial blight
Chilli	*Pusa sadabahar*	Chilly mosaic virus, tobacco mosaic virus and leaf curl

- In **mung bean**, resistance to yellow mosaic virus and powdery mildew were induced by mutation.
- Resistance to yellow mosaic virus in bhindi (Abelmoschus esculentus) was transferred from a wild species and resulted in a new variety of A. esculentus called **Parbhani kranti.**
- Hairy leaves in several plants are associated with resistnace to insect pests, e.g. resistnace to jassids in cotton and cereal leaf beetle in wheat.

- In wheat, solid stems lead to non-preference by the stem sawfly and smooth leaved and nector-less cotton varieties do not atract bollworms.
- High aspartic acid low nitrogen and sugar content in maize leads to resistance to maize stem borers.
- Some crop varieties developed by hybridisation and selection for insect pest resistance are given below.

Plant breeding for developing resistance to insect pests

Crop	Variety	Insect Pests
Brassica	Pusa Gaurav (rapeseed mustard)	Aphids
Flat bean	Pusa Sem 2, Pusa Sem 3	Jassids, aphids and fruit borer
Okra (Bindi)	Pusa Sawani Pusa A-4	Shoot and fruit borer

- **Biofortification→** Breeding crop with higher levels of vitamin, minerals, protein and healthier fats for improving public health.
- "Atlas 66" Wheat variety having high protein content has been used as a donor for improving cultivated Wheat.
- **Explant→** Any plant part that is excised from its original location and used for initiating a culture.
- The capacity to generate a whole plant from any cell/explant is called **totipotency**.
- Micropropagation is the method of producing thousands of plants through tissue culture is called **micropropagation.**
- Plants produced by tissue culture method are called **somaclones.**
- A hybrid produced by fusion of somatic cells of two species/varieties is called **somatic hybrid.**
- The process of production of somatic hybrid is called somatic hybridisation.
- Trichoderma is a free living fungi and it is effective biocontrol agent of several fungal pathogens.
- Baculoviruses (genus-nucleopolyhedrovirus NPV) are biological control patnogen that attack insects and other orthropods.
- These virus are excellent candidates for species-specific narrow spectrum insecticidal applicaiton.
- Biofertiliser are organisms that enrich the nutrient quality of soil.
- Many Members of the genus **"Glomus"** form mycorrhiza.

DOMESTICATION OF ANIMALS

Animal husbandry is the agricultural practice of breeding and raising livestock like buffalo, cow, sheep, horse, camel etc) Animal husbandry also includes poultry farming and fisheries.

More than 70 percent of the world livestock population is in India and China but their contribution to the world farm produce is only 25 percent (ie. the productivity per unit is very low)

Milk yield is primarily dependent on the quality of breeds in the farm.

Poultry farm management

Poultry is the class of domesticated fowl (birds) used for food or for their eggs.

Poultry includes chicken and ducks and sometimes turkey and geese.

Animal breeding aims at increasing the yeild of animals and improving the desirable qualities of the produce.

Inbreeding : Mating of more related individuals within the same breed for 4-6 generations.

Inbreeding increases homozygosity.

Inbreeding exposes harmful recessive genes that are eliminated by selection. It also helps in accumulation of superior genes and elimination of less desirable gene.

Continued and close inbreeding usually reduces fertility and even productivity. This is called **Inbreeding depression.** This problem is overcome by out-crossing.

Out-breeding : Is the breeding of the unrelated animals (either of same breed or different breed or different species)

Out-cossing : Mating of animals within the same breed but having no common ancestors on either side of their pedigree upto 4-6 generations. It is the best breeding method for animals that are below average in productivity (Milk & Meat)

Cross-breeding : Superior males of one breed are mated with superior females of another breed. Many new animals breeds are developed by this approach.

eg Hisardale a new breed by sheep developed by Crossing Bikaneri ewes and Merino rams.

Interspecific hybridisation : Mating between males and females of two different species.

eg Mule = Male Donkey X.Female Horse

Artificial insemination (AI) :

(1) Semen collected from the male (chosen as a parent) is injected into the reproductive tract of the selected female.

(2) A.I. helps to overcome several problems of normal matings.

MOET (Multiple ovulation embryo transfer technology) :

(1) Cow is adminstered hormones to induce follicular maturation and superovulation. (6-8 eggs)

(2) Cow is mated with elite bull or artificially inseminated.

(3) The fertilised eggs at 8-32 all stages are recovered nonsurgically and transferred to surrogate mothers.

(4) This method is used to increase herd size in a short time.

Bee keeping or Apiculture : Is the maintenance of hives of honeybees for the production of honey. (Bee wax is also obtained)

Bees are the pollinators of many of our crops species. Keeping beehives in crop fields during flowering period increases pollination efficiency and improves the yield.

Honey Bee show polymorphism and division of labour.

Fisheries is an industry devoted to the catching, processing or selling of fish, shellfish or other aquatic animals.

Fresh water fish : Catla, Rohu & Common carp

Marine fish : Hilsa, Sardines, Mackerel and Pomfrets.

Blue revolution is an effort to increase fish yield.

MICROBES IN HUMAN WELFARE

Microbes in Household products

1. Curd :

$$\text{Milk} \xrightarrow{\text{LAB}} \text{Curd}$$

(1) During growth LAB produce acids that coagulate and partially digest the milk protein.

(2) LAB increase vitamin B_{12} and check diseases causing microbes in stomach.

2. $\text{Dough} \xrightarrow[\text{Fermentation}]{\text{Baker yeast}} \text{Bread}$

Puffed up appearance of Dough is due to production of CO_2 gas.

3. Cheese : Different varieties of cheese are known by their characterstic texture, flavour and taste. The Specificity coming from the microbes used.

Type of cheese :

1. Unripened cheese.
2. Ripened cheese. e.g. Roquefort cheese, Swiss cheese.

Microbes in industrial products :

1. Fermented Beverages :

1.	Bear	Barley	4-6%
2.	Wine	Grapes	10-20%
3.	Brandy	Distillation of wine	55-60%
4.	Rum	Molasses	40-45%
5.	Whisky	Cereal	20-40%
6.	Gin	Secale cerealae	40%

2. Antibiotics (Anti = against, bio = life)

Penecillin :

1. First discovered antibiotics.
2. Discovered by Alexander Fleming.
3. Full potential of penecillin was established by Ernest chain and Howard Florey.

3. Chemical, Enzymes and other Bioactive molecules.

	Organic acid	**Microbes**
1.	Citric acid	Aspergillus niger
2.	Acetic acid	Acetobacter aceti
3.	Butyric acid	Clostridium butylicum
4.	Lactic acid	Lactobacillus

Enzymes :

1. Lipases : Used in detergents for removing oily stains from the laundry.
2. Pectinases and proteases : For clearing bottled juices.
3. Streptokinase (Clot buster) : Used for a removing clots from the blood vessels

Bioactive molecules :

1. Cyclosporin A : Used as an immunosuppressive agent in organ - transplant patients (produced from fungus Trichoderma polysporum)
2. Statin : Blood cholestrol lowering agents. (From yeast = Monascus purpureus)

Microbes in production of biogas :

1. Biogas is a mixture of gases (containing predominantly methane) produced by the microbial activity and which may used as fuel.
2. The type of gas produced depends upon the microbes and the organic substrates they utilise.
3. Methanogens grow anaerobically on cellulosic material, produce large amount of methane along with CO_2 and H_2.
4. Methanogens present in rumen of cattle help in breakdown of cellulose.
5. Dung of cattle is rich in the bacteria so dung can be used for generation of biogas (Gobar gas).

Microbes as biocontrol agents :

Biocontrol refers to the use of biological methods (Not chemical) for controlling plants diseases and pests.

Biological control of pests deseases.

Biological control method of controlling diseases relies on nature predation not on chemicals. Chemical methods kill both useful and harmful life form this method will greatly reduced our dependence on toxic chemicals and pesticides.

	Biological control agent	**Used to control**
1.	Ladybird Beetle	Aphids
2.	Dragonflies	Mosquitoes
3.	Bacteria **(Bacillus thuringiensis)** (Available in sachets as dry spores)	Butterfly caterpillars
4.	Fungus **(Trichoderma)**	Several plant pathagens
5	Baculoviruses (NPV) (They are speices specific and narrow spectrum)	Insects and other arthropods

Microbes as biofertilisers :

Biofertilisers are organisms that enrich the nutrient quality of the soil. The main sources of biofertilizers are Bacteria fungi and cyanobacteria.

Bacteria	–	**Rhizobium** (symbiotic), **Azospirillum, Azotobacter** (free living)
Fungi	–	**Mycorrhiza**
Cyanobacteria	–	**Anabaena, Nostoc, Oscillatoria,**

(Autotrops used in paddy fields)

In organic farming biofertilisers are used instead of chemical fertiliser.

BIOTECHNOLOGY : PRINCIPLES, PROCESSES & APPLICATIONS

Genetic engineering (Recombinant DNA Technology) :

- It is a type of biotechnology involving manipulation of DNA.
- Biotechnology deals with techniques of using live organisms or enzymes from organisms to produce products & processes useful to humans.
- Genetic engineering involves techniques to alter the chemistry of genetic material (DNA & RNA) to introduce these into host organism and thus change the phenotype of host organism.
- **Stanley Cohen & Herbert Boyer (1972)** first of all constract recombinant DNA by joining an antibiotic resistance gene to the plasmid of ***Salmonella typhimurium***.
- **Paul Bergh** (Father of genetic engineering) transferred a gene of SV-40 virus into ***E.coli*** with the help of λ-phage vector.
- There are three basic steps in genetically modifying an organism :-
  - (i) Identification of DNA with desirable genes.
  - (ii) Introduction of the identified DNA into the host.
  - (iii) Maintenance of introduced DNA in the host & transfer of the DNA to its progeny.

TOOLS OF RECOMBINANT DNA TECHNOLOGY :

- Four types of tools are required :

(1)	Enzymes	(2)	Vectors
(3)	Passenger DNA	(4)	Host cells

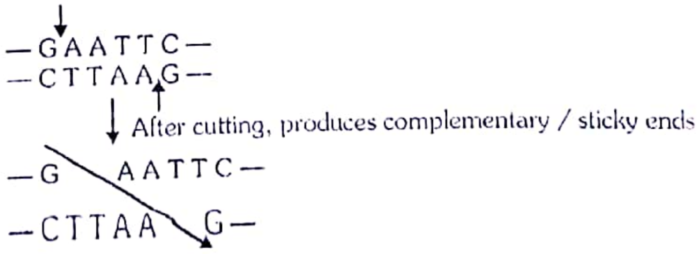
(1) Enzymes : Five different enzymes are generally required.

(a) Lysing enzyme : Required for lysis of the cells. e.g. Lysozyme.

(b) Cleaving enzyme : Required for cutting of DNA molecules.

- **Restriction endonuclease** enzymes are used for this purpose.
- They are also known as **'molecular scissor'**
- The first restriction endonuclease discovered was **Hind-II**.
- All the restriction endonuclease are naturally found in bacteria as a part of their defence system.'
- All restriction enzymes cuts DNA at specific base sequence known as recognition / restriction sequence.
- More than 900 restriction enzymes have been isolated from over 230 strains of bacteria.
- In the naming of these enzymes, first letter of name comes from genes & second two letters from species of bacteria. The fourth letter indicates strain of bacteria. Roman number following the names indicates the order in which the enzyme were isolated from that strain of bacteria.
- The restriction site of these enzyme is a specific pallindromic nucleotide sequence in the DNA.
- Restriction enzyme cut the strand of DNA either a little away from centre of the pallindrome sites or in the centre of the pallindrome site. Thus they produce either sticky ends or blunt ends of DNA.

e.g. EcoRI obtained from *E.coli* RY13. Its restriction site is



(c) **Synthesizing enzyme :** Required for synthesis of DNA.

e.g. DNA polymerase, Reverse transcriptase.

(d) **Joining enzyme :** Required for joining of DNA segments. e.g. DNA ligase.

(e) **Alkaline phosphatase :** It cut off phosphate group from the 5' end of linearised circular DNA & prevents its recircularization.

(2) Vector / Vechicle DNA :

- They are the DNA used as carrier for transferring a fragment of DNA into suitable host cell.
- A vector must have following three features :

(i) **Presence of 'Ori'** to start the replication.

(ii) **Selectable marker** like Amp^R gene, tet^R gene etc. for selection of recombinant host cells.

(iii) **Cloning / Restriction sites,** Where restriction enzyme can cut it.

Some important vectors are :

(a) **Plasmids** (capacity - 0.5 to 8 kpb)

e.g. pBR322 of ***E.coli***

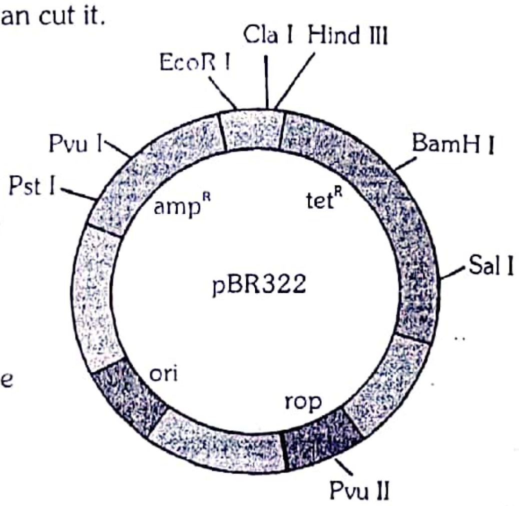
Ti-plasmid of ***Agrobacterium tumifaciens*** which act as natural genetic engineer for gene transfer in plants.

(b) Bacteriophage (capacity = 9-23 kbp), e.g. – λ-phage

(c) Cosmid (capacity = 30-45 kbp)

(d) BAC (capacity = 50-300 kbp)

(e) YAC (capacity = 1000-2500 kbp)



(3) Passenger DNA :

- It is the desired gene/DNA which is transferred from one to other organism by combining it with vector DNA.
- The passenger DNA can be :

(i) Complementary DNA (c-CNA) synthesized on mRNA by reverse transcriptase.

(ii) Synthetic DNA (sDNA) synthesized artificially *in vitro* conditions.

(iii) Random DNA obtained by cleaving DNA with the help of restriction endonuclease enzyme.

(4) Host cells :

- These are the cells in which desired gene in transferred.
- They may be **Bacterial cell, Yeast cell, Plant cell** or **Animal cell.**

PROCESSES OF RECOMBINANT DNA TECHNOLOGY :

- Recombinant DNA technology involves several steps in specific sequence. These steps are :-

(1) Isolation of genetic material / Desired gene :

- This can be achieved by treating the cells with lysing enzyme such as lysozyme (for bacteria), cellulase (for plant cells), chitinase (for fungus) etc.
- From the obtained protoplasm RNA is removed by ribonuclease, proteins by proteases & other - molecules by appropriate treatment.
- The purified DNA ultimately precipitated out after the addition of chilled ethanol.

(2) Cutting of DNA at specific locations :

- Restriction enzyme digestions are performed by incubating purified DNA molecules with restriction enzymes.
- Agarose gel electrophoresis is employed to check the progression of restriction enzyme digestion.
- DNA is a negatively charged molecule, hence in gel electrophoresis it moves towards the positive electrode (anode).
- The DNA fragments separates according to their size through the sieving effect provided by agarose gel.
- The separated DNA fragments can be observed as bright orange coloured bands only after staining the DNA with ethidium bromide followed by exposure to UV light.
- The separated bands of DNA are cut out from gel & extracted from gel piece. This step is known as **elution.**

(3) Amplification of Desired gene using PCR :

- The separated desired gene is than amplified by using PCR technique (Polymerase chain reaction, invented by Kary Mullis).
- In PCR, multiple copies of the gene is synthesised in vitro using two sets of primers & enzyme DNA polymerase (a thermostable **taq polymerase** enzyme is used which is obtained from ***Thermus aquaticus*** bacteria)
- PCR is a three steps thermal cycle, operated automatically.

  The steps are :

  (i) Denaturation (at 94°C)

  (ii) Annealing (at 52°C)

  (iii) Extension (at 72°C)

(4) Formation of recombinant DNA (r-DNA)

- The desired gene & suitable vector, both are cut out by same restriction enzyme, so that they have complementary sticky ends.
- Both are mixed & enzyme DNA ligase is added. It will join the desired gene with vector DNA and a r-DNA is formed.
- During this process, any one of the gene of vector may get inactivated due to the insertion of desired gene. This is known as **insertional inactivation.**

(5) Insertion of recombinant DNA into the host cells :

- There are several methods of introducing the r-DNA into recipient host cells.
- Recipient host cells are made 'competent' to receive r-DNA.
- Bacterial host cells are treated with specific concentration of a divalent cation like Ca^{2+}, which increases the efficiency with which DNA enters the bacterium through pores in its cell wall.
- r-DNA can then be forced into such cells by incubating the cells with r-DNA on ice, followed by placing them briefly at 42°C (heat shock) and then putting them back on ice.
- If a r-DNA bearing gene for resistance to an antibiotic (e.g. ampicillin) is transferred into ***E.coli*** cells, the host cell become transformed into ampicillin resistant cells.
- After this insertion, all cells are grown on ampicillin containing medium, only transformants will grow & untransformed recipient cells will die.
- The ampicillin resistance gene in this case is called a **selectable marker.**

- In place of antibiotic resistance gene, an enzyme gene (gal-gene) can also used as selectable marker. This gene produces β-galactosidase enzyme which produces blue coloured substance from X-gal (chromogenic colourless substance). Host cells having r-DNA will not produce any colour & thus are identified as recombinant colonies.

Vectorless gene transfer :

(1) **Electroporation :** Creation of pores in plasmamembrane to facilitate entry of foreign DNA.

(2) **Microinjection :** Foreign DNA is directly injected into nucleus of cells.

(3) **Biolistics / Gene gun :** Cells are bombarded with high velocity micro-particles of gold or tungston coated with DNA. It is suitable for plant cells.

(4) **Chemical mediated gene transfer :** Use of PEG (Polyethylene glycol) that help in the uptake of foreign DNA into host cell.

(6) **Obtaining the foreign gene product :**

- In almost all recombinant technologies, the ultimate aim is to produce a disirable protein.
- This is done by multiplying the recombinant cells in a continuous culture system where the used medium is drained out from one side & fresh medium is added from other side to maintain the cells in their physiologically active log/exponential phase.
- Such culture is done is large **bioreactors** (100-1000 litres capacity).
- The desired product is then separated from medium & undergo processing before it is ready for marketing as a finished product.
- These processes are collectively called as **Downstream processing.**

APPLICATIONS OF BIOTECHNOLOGY

1. Application in agriculture :

Three options that can be thought for increasing food production

1. Agro-chemical based agriculture.
2. Organic agriculture.
3. Genetically engineered crop based agriculture.

Plants, bacteria, fungi and animals whose genes have been altered by manipulation are called Genetically Modified Organisms (GMO).

Genetic modifications in plants has

(1) Made crops more tolerant to abiotic stresses (cold, drought, salt, heat)

(2) Reduce reliance on chemical pesticides (pest - resistant plants)

(3) Helped to reduce post harvest losses.

(4) Increased efficiency of mineral usage by plants.

(5) Enhanced nutritional value of food. (Golden rice - Vitamin-A enriched rice)

Bt Cotton :

Some strains of **Bacillus thuringienies** (Bt) produce proteins that kill certain insects such as

Lepidopterans (Tobacco budworm, armyworm)

Colepterans (Beetles)

Dipterans (Flis, mosquitoes)

Bt forms protein crystals, (Toxic insecticidal protein) during a particular phase of their growth.

This toxin exist as inactive protoxins but once ingested by insect it is converted into an active form of toxin due to alkaline pH of the gut. The activated toxin binds to surface of midgut epithelial cells and create pores that causes death of the insect.

Specific Bt toxin genes were isolated from Bt and incorporated into the several crop plants (eg. Cotton, Corn etc.)

The choice of genes depends upon the crop and the targeted pest as most Bt toxins are insect group specific.

The toxin is coded by cry gene.

Protein encoded by gene cry IAc & cry IIAb control cotton bollworm and cry I Ab controls corn borer.

Pest resistant plants :

Several nematodes parasite affect plants and animals.

A nematode **Meloidegyne incognitia** infects the roots of tobacco plants and greatly reduce the yield.

To prevent infestation RNA interference. (RNAi) strategy was adopted.

RNAi is a method of cellular defense in all eukaryotic organism.

In this method nematode specific genes (DNA) that produced both sense and anti-sense RNA was introduced into the host plant.

The two RNA's being complementery to each other formed double stranded RNA (dsRNA) that initiated RNA and allowed silencing of specific m-RNA of the nematods. As a result parasite could not survive in transgenic host plant.

2. Application in medicine :

Genetically engineered insulin

In mammals insulin is synthesised as a prohormone (which contains A, B & C peptide) during maturation C peptide is removed so C-peptide is absent in mature insulin.

The main challange for production of insulin using r-RNA technique was getting insulin assembled into a mature form.

In 1983, Eli Lilly an American company prepared two RNA sequences corresponding to A and B, chains of human insulin and introduced them in plasmids of *E.Coli* to produce insulin chains.

Chain A and B were produced separately and combined by creating disulfide bonds to form human insulin

Gene therapy :

Gene therapy is a collection of method that allows correction of gene defect.

It involves delivery of a normal gene into the individual or embryo to take over the function of and compensate for the non-functional gene.

The first clinical gene therapy was given in 1990 to a 4-years old girl with adenosins deaminase (ADA) deficiency

The lymphocytes from the blood of the patients are grown in a culture outside the body. A functional ADA cDNA (Using a retroviral vector) is then introduced into these lymphocytes which are subsequently returned to the patients.

Patients requires periodic infusion of such genetically engineered lymphocytes because these cells are not immortal.

Molecular diagnosis :

Recombinant DNA technology, PCR and ELISA are some of the technique that are used for early diagnosis. (As early detection is not possible by using conventional method of diagnosis)

Very low concentration of a bacteria or virus (at a time when the symptoms of the disease are not yet visible) can be detected by amplication of their nucleic acid by PCR.

ransgenic animals :

Animals that have had their DNA manipulated to posses and express an extra (foreign) gene are known as transgenic animals

Ex. Transgenic rats, rabbits, pigs, sheep, cows and fish. 95% of all existing transgenic animals are mice.

These are developed for

(i) Study normal physiology and development.

(ii) Study of disease

(iii) Produce bilogical products (First transgenic cow, (1997) Rosie produced human enriched milk (2.4 gm/litre). The milk contained human alpha-lactalbumin.

(iv) Vaccine safety (Transgenic milk are used to test the safety of the polio vaccine)

(v) Chemical safety testing.

thical issues :-

Genetic modification of organism can have unpredictable results when such organisms are into the ecosystem.

Indian government has set up organisation such as GEAC (Genetic engineering Approval Committee), which will make decision regarding the valadity of GM research and safety of introducing GM-organism for public services.

Biopiracy is the use of bio-resouces by multinational companies and other organisation without proper authorisation from the countries and people concerned without compeneatory payment.

Ex. 1. In 1997, an American company got pateint right on Basmati rice.

2. Brazzein protein (of west african plant) was patented in USA.

ECOLOGY

ORGANISM, POPULATION AND ECOSYSTEM

- Ecology is a subject which studies the interactions among organisms and between the organism and its physic (abiotic) environment.
- Key elements that lead to so much variation in the physical and chemical conditions of different habitats a temperature, water, light and soil.
- The productivity and distrubiution of plants is also heavily dependent on water.
- The salt concentration (measured as salinity in parts per thousand) is less than 5 percent in inland wat 30-35 percent in the sea water and > 100 percent in some hypersaline lagoons)Some organisms are toler of a wide range of salinities (euryhaline) but other are restricted to a narrow range (stenohaline).
- **Regulators :** Some organisms are able to maintain homeostasis by physiological (sometimes behavioural al means which ensures constant body temperature, constant osmotic concentration.
- **Conformers :** An overwhelming majority (99 percent) of animals and nearly all plants cannot maintain a consta internal environment. Their body temperature changes with the *ambient* temperature. In aquatic animals, th osmotic concentration of the body fluids changes with that of the *ambient* water osmotic concentration.
- Heat loss or heat gain is a function of surface area. Since small animals have a larger surface area relat to their volume, they tend to lose body heat very fast when it is cold outside then they have to expend m energy to generate body heat through metabolism. This is the main reason why very small animals are ra found in polar regions.
- If the stressful external conditions are localised or remain only for a short duration, the organism has two ot alternatives. (i) Migration (ii) Suspention
- Under unfavourable conditions many zooplankton species in lakes and ponds are known to enter diapause stage of suspended development.
- **Adaptation** is any attribute of the organism (morphological, physioloical, behavioural) that enables the organis to survive and reproduce in its habitat.
- Mammals from colder climates generally have shorter ears and limbs to minimise heat loss. (This is called th Allen's Rule).
- The body compensates low oxygen availability by increasing red blood cell production decreasing the bindin capacity of haemoglobin and by increasing breathing rate.
- Some organism show behavioural responses to cope with variations in their environment.
- Desert lizards bask in the sun and absorb heat when their body temperature drops below the comfort zone move into shade when temperature rise above the comfort zone.
- Some organisms breed only once in their lifetime **(Pacific salmon fish, bamboo)** while others breed m times during their lifetime (most birds and mammals). Some produce a large number of small-sized offspr (Oysters, pelagic fishes) while others produce a small number of large-sized offsprings (birds, mammals)
- Life history traits of organisms have evolved in relation to the constraints imposed by the abiotic and bi components of the habitat in which they live.
- Predator acting as conduits for energy transfer across tropic level.
- Since the invaded land does not have its natural predators. The prickly pear cactus introduced into Austral in the early 1920's caused havoc by spreading rapidly into millions of hectares of rangeland.
- Biological control methods adopted in agricultural pest control are based on the ability of the predator to regula prey population. Predators are also help the in maintaining species diversity in a community by reducin intensity of competition among competing prey species.
- Nearly 25 percent of all insects are known to be phytophagous (feeding on plant sap and other parts of p
- Plants have evolved an astonishing variety of morphological and chemical defence against herbivores. Th (Acacia, Cactus) are the most common morphological means of defence.

- Calotropis grow in abandoned fields. The plant produces highly poisonous cardiac glycosides and that is why you will never see any cattle or goat browsing on the plant.
- **Competition :** Competition occurs when closely related species compete for the same resources that are limiting.
- Resources need not be limiting for competition to occur, in interference competition, the feeding efficiency of one species might be reduced due to the interfering and inhibitory presence of the other species, even if resources (food and space) are abundant. Therefore, competition is best defined as a process in which the fitness of one species (measured in terms of its 'r' the intrinsic rate of increase) is significantly lower in the presence of another species.
- The Abingdon tortoise in Galapagos Islands became extinct within a decade after goats were introduced on the island, apparently due to the greater **browsing** efficiency of the goats.
- Competitive release. A species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species, is found to expand its distributional range dramatically when the competing species is experimentally removed.
- Gause's 'Competitive Exclusion Principle' states that two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior one will be eliminated eventually.
- Resource partitioning. If two species compete for the same resource, they could avoid competition by choosing, for instance different times for feeding or different foraging patterns.
- Parasites may reduce the survival, growth and reproduction of the host and reduce its population density. They might render the host more vulnerable to predation by making it physically weak.
- **Brood parasitism :** in which the parasitic bird lays its egg in the nest of its host and lets the host incubate them.
- The cattle egret and grazing cattle in close association, a sight you are most likely to catch if you live in formed rural areas, is a classic example of commensalism.
- Another example of commensalism is the interaction between sea anemone that has stinging tentacles and the clown fish that live among them.
- An ecosystem can be visualised as a functional unit of nature.
- Vertical distribution of different species occupying different levels is called stratification.
- The components of the ecosystem are seen to function as a unit when you consider the following aspects:
  (i) Productivity (ii) Decomposition (iii) Energy flow (iv) Nutrient cycling.
- Primary production is defined as the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis.
- The rate of biomass production is called productivity. It is expressed in terms of g m^{-2} y r^{-1} or (kcal m^{-2}) yr^{-1}
- Gross primary productivity of an ecosystem is the rate of production of organic matter during photosynthesis.
- Net primary productivity is the available biomass for the consumption to heterotrophs (heabiviores and decomposers). Secondary productivity is defined as the rate of formation of new organic matter by consumers.
- The annual net primary productivity of the whole biosphere is approximately 170 billion tons.
- Productivity of the ocean are only 55 billion tons.
- Dead plant remains such as leaves, bark, flowers and dead remains of animals, including faecal matter, constitute detritus.
- Detritivores (e.g.. earthworm) break down detritus into smaller particles. This process is called fragmentation.
- Bacterial and fungal enzymes degrade detritus into simple organic and inorganic substances. This process is called as catabolism.
- Decomposition is largely an oxygen-requiring process. The rate of decomposition is controlled by chemical composition of detritus and climatic factors.

- Temperature and soil moisture are the most important climatic factor that regulate decomposition.
- Whereas low temperature and *anaerobiosis* inhibit decomposition resulting in build up of organic materials.
- Except for the deep sea hydro-thermal ecosystem, sun is the only source of energy for all ecosystems on Earth
- Plants capture only 2-10 percent of the PAR and this small amount of energy sustains the entire living world.
- We find Unidirectional flow of energy from the sun to producers and then the consumers. This is keeping with the first law of thermodynamics.
- Ecosystems are also not exempt from the Second Law of thermodynamics.
- The detritus food chain (DFC) begins with dead organic matter. It is made up of decomposers which are heterotrophic organisms, mainly fungi and bacteria.
- In an aquatic ecosystem, GFC is the major conduit for energy flow. As against this in a terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain than through the GFC.
- Organisms occupy a specific place in the food chain that is known as their trophic level.
- Each trophic level has a certain mass of living material at a particular time called as the standing crop. The standing crop is measured as the mass of living organisms (biomass) or the number in a unit area. The biomass of a species is expressed in terms of fresh or dry weight. Dry weight is more accurate.
- The trophic level represents a functional level, not a species as such.
- In most ecosystem all the pyramids of number of energy and biomass are upright.
  Exception : Pyramid of number of large tree.
- The pyramid of biomass in sea is also generally inverted.
- There are certain limitations of ecological pyramids such as it does not take into account the same species belonging to two or more trophic levels. It assumes a simple food chain, something that almost never exists in nature. It does not accommodate a food web. Moreover, saprophytes are not given any place in ecological pyramids even though they play a vital role in the ecosystem.
- Community that is in near equilibrium with the environment is called a **climax community**. The gradual and fairly predictable changes in the species composition of a given area is called **ecological succession**. The entire series of seral communities of succession is called **sere.**
- Succession is a process that starts where no living organisms are there, these could be areas where no living organisms ever existed. say bare rock; or in areas that somehow, lost all the living organisms that existed there. The former is called primary succession, whether the latter is termed secondary succession.
- Examples of areas where primary succession occurs are newly cooled lava, bare rock, newly created pond or reservoir.
- Secondary succession begins in areas where natural biotic communities have been destroyed such as in abandoned farm lands, burned or cut forests, land that have been flooded.
- **Hydarch succession** takes place in water (water logged) areas and the successional series progress from hydric to the mesic conditions. As against this, ***Xerarch succession*** takes place in dry areas and the series progress from xeric to mesic conditions. Hence, both Hydarch & Xerarch successions lead to medium water conditions (mesic) neither too dry (Xeric), nor too wet (hydric)
- The species that invade a bare area are called **pioneer species.**
- The amount of nutrients, such as carbon, nitrogen, phosphorus, calcium. etc., present in the soil at any given time, is referred to as the **standing state**.
- The movement of nutrient elements through the various components of an ecosystem is called **nutrient cycling**. Another name of nutrient cycling is **biogeochemical** cycles.
- The reservoir for gaseous type of nutrient cycle (e.g. nitrogen etc.) exists in the atmosphere and for the sedimentary cycle (e.g., sulphur and phosphorus cycle), the reservoir is located in Earth crust.
- We find that **71 percent carbon is found dissolved in oceans.**
- According to one estimate **4×10^{13} kg of carbon** is fixed in the biosphere through photosynthesis annually.
- **Two major** and important **differences** between carbon and phosphorus cycle are firstly, atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs and secondly gaseous exchanges of phosphorus between organism and environment is are negligible.

- Researchers and scientists have put an average price tag of US $ 33 trillion a year on fundamental ecosystem services.
- Out of the total cost of various ecosystem services, the soil formation accounts for about 50 percent and contributions of other services like recreation and nutrient cycling are less than 10 percent each. The cost of climate regulation and habitat for wildlife are about 6 percent each.

BIODIVERSITY AND CONSERVATION

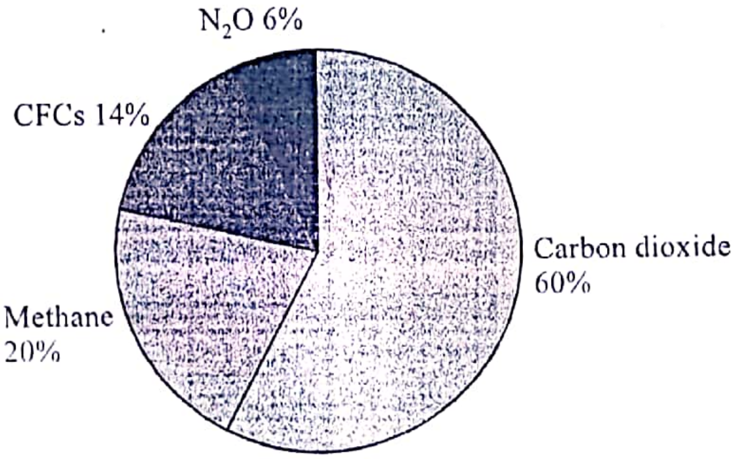
- Biodiversity is the term popularised by the sociobiologist Edward Wilson to describe the combined diversity at all the levels of biological organisation. The most important of them are :
  (i) Genetic diversity (ii) Species diversity (iii) Ecological diversity
- According to the IUCN (International union for conservation of nature and natural resources) (2004), the total number of plant and animal species described so far is slightly more than 1.5 million.
- A more conservative and scientifically sound estimate made by **Robert May** places the global species diversity at about (70 lakh).
- More than 70 percent of all the species recorded are animals, while plants including algae, fungi, bryophytes, gymnosperms and angiosperms comprise no more than 22 percent of the total. Out of every 10 animals on this planet, 7 are insects.
- Although India has only 2.4 percent of the world's land area, its share of the global species diversity is an impressive 8.1 percent.
- India has more than 1,200 species of birds.
- The largely torpical Amazonian rain forest in South America has the greatest biodiversity on earth.
- Reasons for greater biodiversity of tropics are : (a) Tropical latitudes have remained relatively undisturbed with respect to environmental changes for millions of years and thus, had a long evolutionary time for species diversification, (b) Tropical environments, unlike temperature ones, are less seasonal, relatively more constant and predictable. Such constant environments promote niche specialisation and lead to a greater species diversity (c) There is more solar energy available in the tropics, which contributes to higher productivity.
- A stable community should not show too much variation in productivity from year to year, it must be either resistant or resilient to occasional disturbances (natural or man-made) and it must also be resistant to invasions by alien species.
- **Tilman** found that plots with more species showed less year-to-year variation in total biomass. he also showed in his experiments that Increased diversity contributed to higher productivity.
- The IUCN Red List (2004) documents the extinction of 784 species (including 338 vertebrates, 359invertebrates and 87 plants) in the last 500 years. Some examples of **recent extinctions** include the **dodo (Mauritus), quagga (Africa), thylacine (Australia). Steller's Sea Cow (Russia)** and **three subspecies (Bali, Javan, Caspian) of tiger.**
- Presently, 12 percent of all bird species, 23 percent of all mammal species, 32 percent of all amphibian species and 31 percent of all gymnosperm species in the world face the threat of extinction.
- **Causes of biodiversity losses :-**
  (i) Habitat loss and fragmentation
  (ii) Over-exploitation : Steller's sea cow and passenger pigeon were extinct due to overexploitation by humans.
  (iii) Alien species invasion : Threat was posed on native species by invasive weed species like **carrot grass (Parthenium), *Lantana*** and **water hyacinth (*Eicchornia*).** In India the recent illegal introduction of the Aftican catfish ***Clarias gariepinus*** for aquaculture purposes is posing a threat to the indigenous catfishes in rivers.
  (iv) Coextinctions :
- Amazon forest is estimated to produce, through photosynthesis, 20 percent of the total oxygen in the earth's atmosphere, this forest is called the **'lungs of the planet'.**

- **'Biodiversity hotspots'** regions with very high levels of species richness and high degree of endemism (that is, species confined to that region and not found anywhere else). Initially 25 biodiversity hotspots were identified but subsequently nine more have been added to the list, bringing the total number of biodiversity hotspots in the world to 34. These hotspots are also regions of accelerated habitat loss. Three of these hotspots - Western Ghats and Sri Lanka. Indo-Burma and Himalayas cover India's high biodiversity regions.
- India has 14 biosphere reserves, 90 national parks and 448 wildlife sanctuaries.
- **Sacred groves** are found in Khasi and Jaintia Hills in Meghalaya, Aravalli Hills of Rajasthan, Western Ghat regions of Karnataka and Maharastra and the Sarguja, Chanda and Bastar areas of Madhya Pradesh. In Meghalaya, the sacred groves are the last refuges for a large number of rare and threatened plants.
- The historic convention on Biological Diversity **(The Earth Summit)** held in **Rio de Janeiro in 1992**, called upon all nations to take appropriate measures for conservation of biodiversity and sustainable utilisation of its benefits.
- The **World Summit on Sustainable Development** held in **2002 in Johannesburg. South Africa**, 190 countries pledged their commitment to achieve by 2010, a significant reduction in the current rate of biodiversity loss at global, regional and local levels.

ENVIRONMENT ISSUES

- In order to control environmental pollution, the government of India has passed the **Environment (Protection) Act, 1986** to protect and improve the quality of our environment.
- There are serveral ways of removing particulate matter; the most widely used of which is the **electrostatic precipitator**, which can remove over 99 percent particulate matter present in the exhaust from a thermal power plant.
- A **scrubber** can remove gases like sulphur dioxide. In a scrubber the exhaust is passed through a spray of water or lime.
- According to **Central Pollution Control Board (CPCB).** particulate size 2.5 micrometers or less in diameter (PM 2.5) are responsible for causing the greatest harm to human health.
- Automobiles are a major cause for atmospheric pollution atleast in the metro cities.
- **Catalytic converters,** having expensive metals namely **platinum-palladium** and **rhodium** as the catalysts, are fitted into automobiles for reducing emission of poisonous gases. As the exhaust passes through the catalytic converter, unburnt hydrocarbons are converted into carbon dioxide and water, and carbon monoxide and nitric oxide are changed to carbon dioxide and nitrogen gas respectively.
- All the buses of Delhi were converted to run on CNG by the end of 2002.
- Euro II norms, for example stipulates that sulphur be controlled at 350 parts per million (ppm) in diesel and 150 ppm in petrol. Aromatic hydrocarbons are to be contained at 42 percent of the concerned fuel. The goal, according to the roadmap is to reduce sulphur to 50 ppm in petrol and diesel and bring down the level to 35 percent.
- In India, the **Air (Prevention and Control of Pollution) Act** came into force in 1981, but was amended in 1987 to include noise as an air pollutant.
- The Government of India has passed the **Water (Prevention and Control of Pollution) Act 1974** to safeguard our water resources.
- A mere 0.1 percent impurities make domestic sewage unfit for human use.
- **Water hyacinth (*Eichhornia crassipes*)**, the world most problematic aquatic weed, also called **'Terror of Bangal'.** They grow abundantly in eutrophic water bodies, and lead to an imbalance in the ecosystem dynamics of the water body.
- **Biomagnification** refers to increase in concentration of the toxicant at successive trophic levels. Eg: The concentration of DDT is increased at successive trophic levels ; say if it starts at 0.003 ppb (ppb = parts per billion) in water, it can ultimately reach 25 ppm (ppm = parts per million) in fish eating birds, through biomagnification.

- **Eutrophication** is the natural aging of a lake by biological (nutrient) enrichment of its water.
- The natural aging of a lake may span thousands of years. However, pollutants from man's activities like effluents from the industries and homes can radically accelerate the aging process. This phenomenon has been called **Cultural or Accelerated Eutrophication**.
- Collabarating with Biologists from the Humboldt State University, the towns people in the town of Arcata in California, created an integrated waste water treatment process within a natural system, the biologists developed a series of six connected marshes over 60 hectares of marshland. Appropriate plants, algae, fungi and bacteria were seeded into this area, which neutralise, absorb and assimilate the pollutants. Hence, as the water flow through the marshes, it gets purified naturally. A citizens group called **Friends of the Arcata Marsh** (FOAM) are responsible for the upkeep and safeguarding of this wonderful project.
- Ecological Sanitation (EcoSan) is a sustainable system for handling human excreta, using dry composting toilets. EcoSan toilets are used in many areas of Kerala and Sri Lanka.
- **Polyblend**, a fine powder of recycled modified plastic. This mixture is mixed with the bitumen that is used to lay roads.
- The use of **incinerators** is crucial to disposal of hospital waste.
- Irreparable computers and other electronic goods are known as **electronic wastes (e-wastes)**
- It was realised that the use of **nuclear energy** has two very serious inherent problems. The first is accidental leakage, as occurred in the **Three Mile Island** and **Chernobyl incidents** and the second is safe disposal of radioactive wastes.



Relative contribution of various green house gases to total global warming.

- During the past century, the temperature of Earth has increased by 0.6°C.
- **'Bad' ozone,** formed in the lower atmosphere (torposphere) that harms plants and animals. There is **'good' ozone** also, this ozone is found in the upper part of the atmosphere called the **stratosphere**.
- The ozone hole over Antarctica develops each year between late August and early October.
- In human eye, cornea absorbs UV–B radiation, and a high dose of UV-B causes inflammation of cornea called **snow-blindness.**
- An international treaty, known as the **Montreal Protocol**, was signed at Montreal (Canada) in 1987. (effective in 1989) to control the emission of ozone depleting substances.
- Irrigation without proper drainage of water leads to waterlogging in the soil.
- Waterlogging and soil salinity are some of the problems that have come in the wake of the Green Revolution.
- **National Forest Policy (1988)** of India has recommended 33 perent forest cover for the plains and 67 percent for the hills.
- Realising the significance of participation by local communities, the Government of India in 1980s has introduced the concept of **Joint Forest Management (JFM)** so as to work closely with the local communities for protecting and managing forests.

Together, we will make a difference.

Sitting: **Govind Maheshwari (Director), Rajesh Maheshwari (Director)**
Standing: **Naveen Maheshwari (Director), Brajesh Maheshwari (Director & H.O.D. Physics)**

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